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GOVERNMENT OF INDIA

SCIENTIFIC REPORTS
of the
Indian Agricultural Research Institute
for the year ending 30th June, 1957

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COMMONWEALTH MYCOLOGICAL INSTITUTE
15 JAN 1960

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Part I

REPORT OF THE DIRECTOR

1. (a) INTRODUCTORY

A new feature introduced during the year was the decision to publish research reports on specific lines of investigation for the benefit of workers in the States. In the course of investigations, a good deal of data accumulate, which are normally published in scientific journals on the completion of the work. This often takes considerable time. The periodical issue of cyclostyled reports on researches in progress at this Institute would facilitate an early circulation of the data, to the extent they have accumulated, for the use of other research workers in the line. The first report on "Comparison of methods for...available phosphorus in Indian Soils (Soil testing for phosphorus)" is expected to issue shortly.

There was further expansion of research activity under the Second Five Year Plan for stepping up agricultural research which would ultimately enhance food production in the country. Notable among these were researches using radio-active isotopes for tracer studies and for inducing mutagenesis. Considerable interest having been created in the country in this line of study, there is a definite demand for the training of scientific personnel in the various techniques involved. Consequently, a regular three-month course of training is now being organised at this Institute for the benefit of workers from the States. The coordinated scheme on hybrid maize, sponsored by the Indian Council of Agricultural Research and in which work the Rockefeller Foundation is cooperating, started functioning during the year. Consideration was given to the planning of the project for the establishment of a post-graduate school on the most modern lines as a wing of the Indian Agricultural Research Institute. For initiating these activities, a "Memorandum of Understanding" had been signed on April 12, 1956, between the Rockefeller Foundation and the Government of India. Another notable feature was the initiation of work on a research project concerning the role of algae in Indian agriculture.

The Section of Horticulture initiated in April 1954 in the Division of Botany, became a separate Division under the Institute during the year under report; the buildings for this Division are however yet to be constructed. To further improve the appearance of the Institute, which is now visited by many distinguished visitors, beautiful trees, shrubs and climbers have been planted. Another interesting activity relates to research in floriculture, which this Institute has been authorised to undertake; among several ornamental flowers, a good start has been made with roses using, in the first instance, the rich personal collection of rose varieties built up by the Director.

1(b) LEAVE, TRANSFERS AND POSTINGS OF GAZETTED STAFF

(i) Directorate

Dr. B. P. Pal continued to be Director of the Institute during the period under report, except for a period of 3 weeks from 2-9-56, when he was deputed as official delegate to attend the International Genetics Symposia held in Tokyo and Kyoto in Japan. Dr. R. S. Vasudeva continued to be Joint Director of the Institute during the period under report. Shri B. M. Pal was appointed as Registrar with effect from 11-8-1956. Shri K. C. Gupta was appointed to officiate as Accounts Officer with effect from 8-2-1957.

(ii) Division of Agronomy

Dr. P. C. Raheja continued to officiate as Head of the Division of Agronomy throughout the year, except for 24 days from 5-2-1957 when he was deputed to attend the meeting of the Advisory Committee on Agricultural Research of the Sudan Government. Dr. Mukhtar Singh was appointed as Agronomist in the scheme, 'Project for Irrigation Investigation', with effect from 28-2-1957 relieving Shri J.J. Chandnani who consequently reverted to his substantive

post of Assistant Agronomist. Shri R. S. Gupta was appointed to officiate as Assistant Agronomist at the Agricultural Substation, Karnal, with effect from 7-7-1956. Dr. P. N. Saxena was appointed as Head of the Section of Statistics with effect from 26-7-1956 and Shri A. G. Kavitkar as Assistant Statistician with effect from 27-12-1956.

(*iii*) *Division of Botany*

Dr. S. M. Sikka continued to be Head of the Division of Botany throughout the year. Shri S. S. Rajan, Assistant Cytogeneticist was deputed for a short course of training in Japan under the Colombo Plan for about 10 months from 16-1-1957. Shri S. Ramanujam, Assistant Cytogeneticist, Embryo-culture Scheme, proceeded on 12 months' special leave, from 22-2-1957, for overseas studies. The following appointments were made in the Division during the year :—

	Name of Officer	*Post*	*Date of appointment*
1.	Dr. S. P. Kohli	Geneticist	19-11-1956
2.	Shri R. B. Deshpande	Geneticist	14-3-1957
3.	,, Krishna Rao	Chemist in the scheme for improvement of essential oil yielding plants	31-8-1956
4.	,, M. V. Rao	Assistant Wheat Breeder, Delhi Centre	28-11-1956
5.	,, Y. M. Upadhyaya	Assistant Wheat Breeder, Pusa Centre	10-12-1956
6.	,, Daljit Singh	Assistant Statistician	27-12-1956
7.	,, B. S. Joshi	Assistant Botanist in the scheme for the improvement of essential oil yielding plants, Delhi Centre	14-12-1956
8.	,, M. G. Joshi	Assistant Botanist in the scheme for the improvement of essential oil yielding plants, Pusa Centre	15-4-1956
9.	,, P. M. Bhagchandani	Assistant Botanist in the scheme for the improvement of essential oil yielding plants, Katrain Centre	16-3-1957
10.	,, L. M. Jeswani	Assistant Botanist in the scheme for the improvement of essential oil yielding plants, Aliabada Centre	16-12-1957
11.	,, M. W. Hardas	Assistant Geneticist	23-8-1956
12.	,, R. K. Mehta	Assistant Geneticist	11-3-1957
13.	Dr. Vishnu Swarup	Assistant Geneticist	8-10-1956
14.	Shri G. S. Venkataraman	Assistant Botanist in the Algae Scheme	28-12-1956
15.	,, S. P. Singh	Assistant Physiologist	17-1-1957

(*iv*) *Division of Horticulture*

Dr. G. S. Randhawa was appointed as Horticulturist and Dr. Jagpal Singh as Assistant Horticulturist with effect from 21-7-1956 and 20-8-1956, respectively. Dr. B. Chowdhury was appointed as Vegetable Breeder with effect from 14-5-1957.

(*v*) *Division of Soil Science and Agricultural Chemistry*

Dr. S. P. Raychoudhury continued to be Head of the Division of Chemistry throughout the year. Dr. B. V. Subbiah, Assistant Soil Chemist, was deputed for a short course of training

in the U.S.A. under the E.T.A.P. Scheme of the F.A.O., for about 6 months from 13-3-1957. The following appointments were made in the Division during the year :—

	Name of Officer	*Post*	*Date of appointment*
1.	Dr. B. Ramamurthy	Physical Chemist	18-7-1956
2.	,, Y. V. Kathawate	Experimental Physicist	25-1-1957
3.	,, N. C. Mehta	Soil Survey Officer (Collection and Collation of Soil Survey Data Scheme).	1-5-1957
4.	,, K. V. Satyanarayana	Soil Correlator, Delhi Centre	28-8-1956
5.	,, B. B. Roy	Soil Correlator, Hyderabad Centre	8-1-1957
6.	Shri S. Digar	Soil Correlator, Kharagpur Centre	1-1-1957
7.	Dr. C. Dakshinamurthy	Senior Physicist	26-7-1956
8.	Dr. S. C. Das	Assistant Physical Chemist	11-12-1956
9.	Shri V. K. Misra	Assistant Soil Chemist, Nagpur Centre	10-9-1956
10.	,, B. B. Rudra	Assistant Soil Chemist, Calcutta Centre	23-10-1956
11.	,, T. R. Srinivasan	Assistant Soil Chemist, Coimbatore Centre	1-9-1956
12.	,, Bhagwan Das	Assistant Soil Chemist, Ludhiana Centre	14-2-1957
13.	,, N. R. Dutta Biswas	Assistant Soil Chemist, Sabour Centre	26-8-1956
14.	,, G. C. Padhi	Assistant Soil Chemist, Cuttack Centre	26-10-1956
15.	,, P. M. Joshi	Assistant Soil Chemist, Himayat Sagar Centre	1-9-1956
16.	,, H. G. Gopala Rao	Assistant Soil Chemist, Bangalore Centre	1-9-1956
17.	,, K. L. Nayyar	Assistant Soil Chemist, Patiala Centre	1-9-1956
18.	,, H. Sankara Subramanian	Assistant Soil Chemist Trivandrum Centre	6-10-1956
19.	,, Y. P. Bali	Assistant Soil Chemist, Gwalior Centre	23-8-1956
20.	,, P. C. Thakur	Assistant Soil Chemist, Simla Centre	23-8-1956
21.	,, P. K. Oommen	Assistant Soil Chemist, Delhi Centre	1-5-1957
22.	,, C. S. Jain	Stores Officer	8-2-1957

(vi) Division of Entomology

Dr. E. S. Narayanan continued as Head of the Division of Entomology during the period under report. Dr. S. Pradhan was appointed as Toxicologist in the Main Division from 5-10-56. Shri B. H. Srivastava was appointed as Entomologist in the Scheme for Setting up of Seed Testing Station from 10-10-1956, relieving Shri H. N. Batra, who reverted to the post of Assistant Ecologist from 10-10-1956. Dr. N. C. Pant was appointed as Insect Physiologist in the Scheme for Research on Insect Physiology from 10-8-1956, relieving Dr. Rattan Lall who reverted to the post of Assistant Toxicologist. Dr. Rattan Lall was later appointed as Entomologist in the Scheme for Entomological Investigation with the help of radio-isotopes from 8-6-1956, relieving Shri S. M. Chatterjee, Officiating Entomologist, who reverted to the post of Assistant Systematic Entomologist. Shri Pritam Lal Sharma was appointed as Assistant Entomologist in the Scheme for Research on Indian Honey Bee at the Botanical Sub-station, Pusa, from 1-12-56. Shri Y. P. Beri and Shri R. S. Diwan were appointed to the posts of Assistant Entomologist and Chemist, respectively, in the Scheme for Exploration of Toxicity Hazards, with effect from 17-12-1956 and 24-1-1957 respectively.

(*vii*) *Division of Mycology and Plant Pathology*

Dr. R. S. Vasudeva continued to be Head of the Division of Mycology during the period under report. Dr. R. Prasada, Mycologist, visited Australia for a period of six months for training in wheat rust work under the Colombo Plan. Dr. M. K. Hingorani was deputed to the U.K. for training in bacteridogy under E.T.A.P. of the FAO from 6-2-57. Shri J. N. Kapoor was appointed as Herbarium Keeper from 16-2-1957,-Dr. Gopal Swarup was appointed as Assistant Mycologist in the Wheat Rust Control Scheme on 27-10-56, and Shri M. L. Seth as Assistant Virus Pathologist (Vector) in the Coordinated Virus Disease Scheme on 22-12-56. Shri S. N. Chatterjee assumed charge as Virus Entomologist at the Kalimpong Substation on 16-4-57. Dr. M. R. S. Iyengar, Plant Pathologist in the Scheme for the use of Atomic Energy in Plant Pathological Research, resigned from the post and was relieved on 10-1-57. Dr. D. Suryanarayana was appointed as Plant Pathologist in the Scheme for setting up of Seed Testing Station from 15-9-56. Shri R. L. Munjal was appointed as Mycologist in the Scheme for Appraisal of Losses due to Plant Diseases from 3-6-57, after completing his training in Systematic Mycology in England under a Rockefeller Foundation Scholarship.

(*viii*) *Division of Agricultural Engineering*

Shri R. V. Ramaiah continued as Head of the Division of Agricultural Engineering until 5-10-56 when he was relieved to join the post of Development Officer under the Ministry of Commerce; Shri J. S. Manku, Assistant Engineer was appointed to hold charge of the current duties of the Head of the Division from the same date.

(*ix*) *Central College of Agriculture*

Dr. E. S. Narayanan continued to be the Principal during the year. Shri Diwan Singh was appointed as Lecturer in Agriculture from 28-8-57 when Shri K. P. Misra, who was officiating, reverted to his substantive post. Shri N. Nath was appointed as Lecturer in Horticulture from 21-2-57. Shri S. D. Gera was appointed as Lecturer in Mycology from 20-12-56. Dr. D. Suryanarayana, Lecturer in Mycology, was relieved on 15-9-56 to join the post of Plant Pathologist in the Scheme for setting up of Seed Testing Station in the Mycology Division.

(C) ACCOUNTS DURING 1956-57

The total expenditure of the Institute and its sub-stations at Karnal and Pusa, during the financial year ending March 31st, 1957, amounted to Rs. 37,86,378 as under :—

		Rs.
I.	(*i*) General expenditure on the Institute, including the office of the Director, irrigation, power, supply, gas plant, estate establishment, I.A.R.I. Dispensary etc.	5,24,911
	(*ii*) Division of Agronomy , including Sections of Statistics and Economics	4,70,756
	(*iii*) Division of Botany	6,65,862
	(*iv*) Division of Soil Science and Agricultural Chemistry	8,05,287
	(*v*) Division of Entomology	3,07,146
	(*vi*) Division of Mycology and Plant Pathology	3,85,752
	(*vii*) Division of Agricultural Engineering	2,22,327
	(*viii*) Division of Horticulture	30,815
	(*ix*) Central College of Agriculture	1,73,833
	TOTAL	35,86,689
II.	*Experimental farm*	
	(*i*) Agricultural Research Substation, Karnal	1,23,334
	(*ii*) Botanical Substation, Pusa	76,355
	TOTAL	1,99,689
	Grand Total of I and II	37,86,378

2. SUMMARY OF THE MAIN RESULTS OF RESEARCH (1956-57)

AGRONOMY

(a) Soil Fertility

Increasing doses of P_2O_5 (0, 16, 32 and 64 lbs. per acre) brought about in berseem a progressive and significant increase in the yield of both green fodder and seed. The residual response of P_2O_5, studied on cowpea in the rotation *berseem-cowpea*, was significant with 32 and 64 lb. doses only. The effect of soil fertility, built up through phosphate application to berseem in the presence and absence of potash and nitrogen, was evident in cotton and wheat grown in the *berseem-maize-berseem-cotton-wheat* rotation. The out-turn of potato crop in the rotations, *maize-potato-sugarcane* and *green manure-wheat-fallow potato-sugarcane*, was significantly higher than under *green-manure-potato-maize-peas* rotation. Rotations including berseem, cotton and sugarcane had comparatively less weed infestation than less intensive rotations.

Application of nitrogen, at 0, 20 and 40 lbs. per acre as ammonium sulphate, to wheat in *fallow-wheat* and *bajra-wheat* rotations indicated much higher responses in the latter as compared to the former rotation. Green manure (*guar*), or castor cake at 60 lb. N per acre, increased the yield of wheat by about 2·5 mds. over the control. In the 6-acre holdings, mix farmed under rainfed conditions, the response given by wheat and barley to a side dressing of 30 lb. N plus 20 lb. P_2O_5 was 2·1 and 3·0 mds., respectively.

(b) Field Crops

The research aspects included in this section are (*i*) large scale varietal trials; (*ii*) responses of crops to fertilizers; (*iii*) cultivation and cultural experiments (*iv*) soil conservation and (*v*) grassland improvement.

The wheat variety, N.P. 718, yielded significantly higher than N.P. 710. Sowings on 25th Oct. proved superior to 12th Nov. and 1st December respectively. The best triple factor combination was N.P. 718 sown on 25th October, with 6″ spacing between rows, at a seed rate of 70 lb. per acre.

Placement of phosphate did not increase the yield of wheat over broadcast application. Seed bed preparation with tractor, victory-*cum*-country plough and country plough alone did not show significant differences in yield of wheat.

The sesamum variety, 'S', which has been evolved at this Institute and which is partially tolerant to phyllody, showed better performance than 14 other varieties obtained from various sources in the country.

In linseed, nitrogen alone indicated a response with the varieties, N.P. 12, N.P. (R.R.) 10 and N.P. (R.R.) 236. The response to phosphate was very small; phosphate alone showed a depressing effect.

The grasses, *Panicum antidotale* and *Chloris gayana*, showed high and significant responses to nitrogen at varying levels. A combination of 120 lb.N. and 40 days' interval of cutting gave the maximum yield of 427 mds./acre of *Panicum antidotale*. In *Chloris gayana*. the highest yield of 256.79 mds. per acre was obtained with 120 lb. N. and 20 days' interval of cutting. In a premilinary trial, *Brachiaria mutica* (A-2996), *Dichanthium caricosum* (A-2976), *Panicum virgatum* (A-2535), *Pennisetum ciliaris* (A-2814), *Pueraria spp.* and *Desmodium tertuosum* showed promise. In trials conducted at eight centres representing distinct agro-climatic conditions, the grasses, *Setaria sphacelata*, *Urochloa sp.*, *Chloris gayana* (Giant Rhodes), *Cenchrus ciliaris* and *Panicum coloratum* gave superior performances.

(c) Vegetables and commercial crops

The investigations in progress include (*i*) fertilizer experiments on tomato and cauliflower, (*ii*) varietal, fertility and cultivation experiments on sugarcane, (*iii*) fertilizer experiment on potato and peas, and (*iv*) economics of 3-acre vegetable growers' holdings.

Optimum yield of cauliflower was obtained with 40 lb. N plus 40 lb. P_2O_5 per acre. The garden pea variety Bonneville, yielded 42·59 mds. grain per acre, which yield is significantly higher than that of N.P. 29 or Early Badger. Response to phosphate increased corresponding to increasing levels of applications. Application of phosphate and potash in conjunction with nitrogen enhanced the yield of potato significantly; the fertilizer mixture, 120 lb. N. plus 80 lb. P_2O_5 plus 40 lb. K_2O per acre, proved to be the best treatment.

In a sugarcane varietal-*cum*-manurial trial, highest yield was obtained from the variety, Co. 647, which was followed by Co. 797, Co. 659, B.O. 11, Co. 739 and Co. 312. Among the nitrogen doses, 120 lb. per acre was significantly better than other levels. The interaction was not significant.

(*d*) *Farm and Cattle*

On the farm, emphasis was laid on the production of foundation seed of improved wheat varieties and on the reduction of cost of production of crops.

The Sahiwal herd maintained the wet and overall averages at fairly high levels, namely 21·3 and 14·8 lb. respectively. Two cows gave over 9200 lb. of milk and two over 8700 lb. per lactation. In a new experiment in which the calves, one month after birth, were fed on skimmed milk, instead of on standardised (3·5 per cent butter fat) milk, it was observed that the calves maintained a normal growth rate of over 1·0 lb. per day.

(*e*) *Statistics*

The designing of field experiments, analysis of experimental data and training of students in agricultural statistics were the chief activities of the Section. In the Sahiwal herd, lactation curves were fitted for the first and the second calves. The association between the variables was slightly weaker for the latter lactation than the former. The cow Tamili, which is the earliest-matured and the highest yielding cow in the Sahiwal herd, recorded an average rate of growth of 6·97 lb. per week from the date of birth to first calving.

In *jowar*, it was found that a 3′ unit length from 5 rows (4·3% sampling) provided a good estimate (plus 4%) of average plant height. Analysis of maize data from the Permanent Manurial Experiment (New Series) indicated that treatment with F.Y.M. 4000 lb., together with 20 lb. N from rape cake, among the organic manures, and N.P.K. treatment, among the fertilizers, raised the yields significantly. Crop cutting experiments carried out in the Delhi village under the Intensive Cultivation Schemes indicated that the wheat variety, N.P. 718, gave 3·4 mds., or 28·1%, more yield than the local.

(*f*) *Fertiliser-use project*

The third report on wheat, as well as a consolidated three year report on this project, were compiled. During 1955-56, the experiments conducted on wheat in eleven community project centres and in the 15-acre-block centres were 713 and 52 respectively. In the complex experiments the average response to 20 lb. nitrogen, applied as ammonium sulphate, was 3·2 mds. per acre. With increase in nitrogen to 40 lb. N the additional response was 1·6 mds. per acre. In these experiments the average responses to the 20 and 40 lb. P_2O_5 per acre were 1·7 and 2·5 mds. respectively. In cultivators fields, the application of 20 and 40 lb. nitrogen to the wheat crop effected an increase in yield of 2·30 and 4·90 mds. per acre, while responses to phosphate at the same levels were respectively, 2·1 and 3·90 mds. per acre. The average response to 20 lb. N plus 20 lb. P_2O_5 was 4·4 mds. per acre. Urea, ammonium chloride, ammonium sulphate-nitrate and ammonium sulphate indicated the same degree of response in yield of wheat.

The total number of paddy experiments conducted from 1953-54 to 1955-56 were 168 (complex) and 2700 (simple). In the complex experiments the average responses to 20 and 40 lb. N levels were 3·3 and 5·0 mds. respectively, while the responses to phosphate at the same levels were 1·9 and 2·8 mds, respectively. The average responses to 20 and 40 lb. N levels were 4·5 and 6·1 mds. per acre respectively. On an all-India basis, the application of 20 lb. N

plus 20 lb. P_2O_5 per acre gave a net profit of Rs. 51 on an investment of Rs. 28, paddy being sold at Rs. 12 per md. Though production was appreciably increased with a dose of 40 lb. N plus 20 lb. P_2O_5 the net profit remained the same. Ammonium sulphate, ammonium sulphate-nitrate and urea at 20 lb. N level were equally effective. Superphosphate and ammonium phosphate performed equally well on alkaline soils of calcareous nature. On acid soils, bonemeal and superphosphate proved equally effective but a mixture of 1/2 super plus 1/2 rock phosphate gave higher response than superphosphate alone.

(*g*) *Irrigation investigations*

Three series of field experiments were conducted with a view to study (*i*)the inter-relation of irrigation, manurial and cultural factors on sugarcane, cotton, wheat and potato, (*ii*) the effect of irrigation intensities on major farm crops (cotton, sugarcane, wheat, berseem, potato and maize) under different cropping patterns and (*iii*) the effect of irrigation intensities in relation to nitrogen manuring under different methods of irrigation, *viz.*, flat, furrow and spray irrigation, on tobacco.

Optimal yields of potato were obtained with 17·5 "delta of water applied in 2" doses of irrigation. No interaction was observed between irrigation intensities and seed rates and between nitrogen levels and seed rates. In cotton, the effect of nitrogen varied significantly with dates of sowing. High, medium and low responses were obtained from nitrogen applications with cotton (Var. H 14) sown on 1st May, 20th May, and 10th June, respectively.

(*h*) *Weed Control investigations*

The investigations covered; (*i*) control of weeds in field crops by cultural and chemical methods, (*ii*) control of prerennial weeds by cultural and chemical means, and (*iii*) relative performance of weedicides.

Post-emergence application of T.C.A. at 9 lb. per acre was as good as hand weeding and hoeing in influencing cotton yields. MCPA application at 6 oz. per acre increased the yield of potato by 23·7 mds. over the control. 2, 4-D, 2.4-DB and M.C.P.A. most effectively controlled the broad-leaved weeds such as *Anagallis arvensis*, *Chenopodium album.* and *Melilotus spp.* T.C.A. at 60 lb. acid equivalent reduced the stand of *Sorghum halepense* by about 33%; 5 cultivations proved best resulting in a 70% reduction in weed population. The corresponding increases in wheat yields were 14% and 29·9% respectively. Application of 1 lb. of 2,4-D, as methoxone, to wheat increased the yield by 3·6 mds. per acre in ten trials conducted on cultivators' fields.

(*i*) *Agricultural Extension*

Eight students, undergoing the newly-organised, 2-year course in Agricultural Extension, collected data pertaining to their respective investigations. They organised a '*Kisan mela*" at the Project Centre in Nangloi, in May, 1957, which was a great success.

In the Intensive Cultivation Scheme the programme of varietal and fertilizer demonstrations was continued. The wheat variety, N.P. 718, saturated an area of 2775 acres as against 2099 acres in 1955-56. 7250 mds. of seed of N.P. 718, from the cultivators plots in the scheme area, was supplied to the Bihar Government.

The fourth Key Village Centre and one Artificial Insemination Centre were set up at Nangloi. Castration operations against scrub bulls were continued in 19 villages. Over 400 buffaloes and 250 cows were served by the bulls stationed at these centres. Necessary advice on the feeding of cattle and treatment of diseases was given to stock breeders in the area.

(*j*) *Seed Supply*

A total of 2935 mds. seed of improved varieties of wheat, oats, barley, gram, peas, berseem, paddy, maize and cowpeas were supplied to the State Governments and individual farmers. In addition, about 2000 mds. of sugarcane setts, 395 seed samples of grasses and legumes and 4000 Kudzu crowns and 76 potted plants were distributed. From the Agricultural Research Substation, Karnal, 1389 mds. of seed were distributed.

Botany

The research work in the different sections of the Botany Division has made satisfactory progress. Improvement of various crop plants including wheat, maize, millets, pulses, oil bearing plants, vegetables, pasture grasses and legumes, etc., has been the main objective of these researches, as in previous years. Work on the improvement of ornamental plants has been initiated, for the first time in India.

For the setting up of a laboratory for testing the milling, baking and *chapati*-making qualities of Indian wheats, the services of Dr. C. C. Fifield, Baking Technologist, U.S.D.A., were made available by the T.C.M. for a short period. The cereal improvement work is being considerably expanded with the collaboration of the Rockefeller Foundation. A new line of work that has been started during the year under an I.C.A.R. scheme is the study of algae useful in agriculture. Other schemes sanctioned under the Second Five Year Plan, as also by the I. C. A. R. and various commodity committees, continued to function satisfactorily.

The more important achievements of the Division during the year under report are mentioned below :—

(*a*) *Plant breeding and genetics*

(*i*) *Breeding for disease resistance and other characters in wheat*

This work was in progress at Delhi and at the Sub-Stations at Simla, Pusa, Indore, Wellington and Bhowali (U.P. Hills). The programme, initiated a few years back to bring in resistance from diverse sources by intervarietal, interspecific and intergeneric hybridization, was continued and large numbers of selections were made which combined in them rust resistance and desirable agronomic characters.

The newly-evolved rust resistant varieties *viz.*, N.P. 797, N.P. 798 and N.P. 799 have continued to give superior performance in yield trials. It is gratifying to note that the strains N.P. 798 and N.P. 799, have shown high rust resistance in Bihar and West Bengal where the damage caused by the disease during the year was a major calamity to the crop. The results of trials in the hills have once again established the superiority of N.P. 770, N.P. 809 and Ridley over the existing varieties under cultivation.

Trials with the recently-evolved strains have confirmed the suitability of HD(52)-46 for different agronomic conditions. Other strains that distinguished themselves in yield performance were HD(52)-70, HD(52)-67 and HD(52)-23 at Delhi, HD(52)-27 at Karnal, HD(53)-87 at Jaipur (Rajasthan) and HD(53)-146 in the lower hills of Himachal Pradesh.

The demand for seeds of N.P. wheats crossed an all time record, and amounted to a little over 13,000 mds., but only about 2500 mds. could be supplied from the stocks available at the Institute and its substations. In addition, about 9,800 mds. of N.P. 718 were supplied from the villages, in Delhi State, covered by the Institutes' Intensive Cultivation Scheme.

(*ii*) *Maize*

The exotic maize hybrid, N.C. 27, double-cross seed of which was produced at this Institute from acclimatised parental inbred lines, gave a grain yield of 75 mds. and 12 seers, as compared to 42 mds. and 7 srs. given by K.T. 41, an improved Indian open-pollinated variety.

In replicated trials with 369 top-crosses and 72 single crosses, the yield increases over the control, K.T. 41, ranged from 206 to 134 per cent in the former and 196 to 135 per cent in the latter, thus indicating the high general and specific combining ability of some of the inbred lines under study.

(*iii*) *Jowar*

A number of promising indigenous types have been crossed with the male-sterile Texas Blackhull Kafir with a view to producing hybrid seed.

(iv) Bajra

Studies on exploitation of hybrid vigour in this crop were continued. In a top-cross trial involving 39 S_1 lines, two top-crosses, *viz.*, I.C. 2386/5 and I.C. 1721/2, were significantly superior in yield to the control, T. 55.

(v) Rust resistant linseed

Further progress was made in breeding early maturing rust resistant strains. The available yield data indicate that some of the new selections are superior to the N.P. (R.R.) strains evolved in previous years; these strains will be further tested on a larger scale.

(vi) Wilt resistant arhar

As a result of progeny-row testing of over 200 promising selections, 14 selections have been obtained which are highly wilt resistant, besides being high yielding and having attractive grains.

(vii) Breeding of long staple cotton (G. hirsutum)

Breeding work for evolving long-stapled strains has yielded good results. Some selections possessing halo length of 28 to 32 mm. and ginning outturn from 29 to 37% have been isolated from a critical study of about 300 indigenous and exotic varieties of *G. hirsutum.*

(viii) Chilli

The strain, Puri Red, was confirmed to be resistant to mosaic disease both under field as well as controlled conditions.

(ix) Essential-oil bearing plants

Work on the improvement of *ajwain*, coriander, cumin, dill and fennel, was continued for the second year at all the four centres, *i.e.*, Delhi, Jamnagar, Pusa and Katrain.

A considerable range of variability in respect of days taken from sowing to flowering, seed size, 100 seed weight and single plant yield etc., was observed in each crop, on the basis of which a large number of promising selections have been made for further trials.

(x) Pasture grasses and legumes

In a yield trial with 64 strains of grasses, *Setaria sphacelata* (E.C. 7431-Australia) and *Brachiaria mutica* (E.C. 9715 Australia) gave the best performance ; the former is drought resistant and the latter appears to be resistant to both drought and cold.

(xi) Vegetables

Work on the improvement of vegetable crops was continued at Delhi and at the Vegetable Breeding Substation, Katrain. The important results in some of the vegetable crops are given below :—

(a) Tomato.—With the object of exploiting hybrid vigour in this crop, a number of F_1 hybrids were tested. The hybrid seeds of Sioux (male-sterile) × Meeruti gave the maximum increase in yield, *viz.*, 50 %, over the average of the parents.

(b) Onion.—A preliminary trial with hybrid onions developed locally indicated the superiority of four hybrids having light red or red bulbs with an average weight of 3·3 to 3·5 oz. per bulb as compared to 2·5 oz. per bulb for the standard variety, Pusa Red.

(c) Sweet Potato.—Norin, a red-skinned sweet potato, has given good performance; it is being multiplied for distribution.

About 5356 lbs. of seeds of different vegetables produced at Delhi, as well as at Katrain were supplied to various indentors.

(xii) Water-melon and musk-melon :

Some of the Japanese varieties of water-melon have shown higher sugar content than the indigenous material. The Japanese seedless water-melon gave satisfactory performance.

(xiii) Vegetable seed testing

Work on the development of rapid techniques for purity and germination tests has indicated that tetrazolium chloride, sodium biselenite and malachite green give results that agree with those obtained by actual germination in petri dishes and in the field.

(xiv) Genetic variability in algae

Extensive collections of fresh water algae have been made from various localities and work on their morphology and systematic identification was being carried out. Algal flora from various depths of both cultivated and uncultivated soils was studied with a view to determine their possible role in soil fertility. It has also been found that some of the algae isolated from the soil are capable of fixing atmospheric nitrogen. Such nitrogen-fixing algae have also been detected, for the first time, in the nodules of berseem.

(b) Cytology and Cytogenetics

(i) Induced polyploidy as a means of crop improvement

In the *toria* tetraploids grown this year, multivalent formation was further reduced, indicating that it should be possible to produce types in which only bivalents are formed and which are therefore more or less fully fertile. Tetraploid berseem was found to maintain its superiority over the diploid varieties. During this year, triploid water melon seed was also produced which should give seedless fruits. Tetraploidy was induced in a number of ornamental plants, including phlox, carnation, cosmos, calendula, and petunia; the tetraploids were found to possess larger and more attractive flowers.

(ii) Induction of mutations in crop plants

Different types of ionising radiations, x-rays, beta rays and neutrons were used for inducing mutations in cotton, wheat, tobacco, potato and several ornamental plants. By this means, the desirable character of awning has been introduced into plants of the awnless wheat varieties, N. P. 797, N. P. 798, N. P. 799, and N. P. 809; male sterility was induced in several cotton plants and better adaptability was created in the potato variety, Up-to-date. This technique has also made possible wide crosses in tobacco which could not be effected previously, and helped to induce interesting floral variations in ornamental plants.

(iii) Culture of excised plant embryos

Media were standardised for the culture of young jute and tomato embryos and the techniques so evolved will be helpful in making wide crosses in these crops for the solution of specific problems.

(iv) Monosomic analysis in wheat

The analysis has confirmed the presence of genes for awning on chromosomes 3,8 and 10 of the wheat variety, Cometa Klein. It was also found that genes for resistance to the Indian races of yellow rust may be situated on chromosomes 4 and 6 of the same variety.

(c) Crop Physiology

Further investigations on drought resistance have indicated that, up to 3 or 4 weeks after anthesis, the rate of increase in grain weight was the same under normal water supply as well as drought; this was due to the fact that although grain number was reduced, grain size was more under drought during this period following anthesis. Furthermore, during this period, the ears were green, although the leaves and stems turned yellow, under both water treatments. In the later stages, grain size was adversely affected by drought due to the fact that under this treatment the ears turned yellow faster than under normal water supply. The results indicate that the desirable attributes in a variety for *barani* cultivation would be high grain number and long functional period of the ears.

(*d*) *Plant introduction*

During the year, 2397 samples of seeds and planting materials were introduced from abroad and 740 were collected from within the country. Amongst the more interesting accessions, mention may be made of the following :—

(*i*) Dorset, a sorghum variety, reported to be bird-resistant; Craigh-all cane sorghum from the U. K., which appears to be drought tolerant and sweet; an early-maturing (55 days) sorghum variety from China (E. C. 8501).

(*ii*) "Munga Potch", a variety of *Pennisetum typhoides*, originally from East Africa, with very impressive ears.

(*iii*) A functional sterile tomato from the U. S. A.

(*iv*) Hybrid onions, along with their male sterile and maintenance lines.

(*v*) Amphidiploid (*Aegilops triuncialis* × *Triticum timopheevi*), from the U.K., resistant to rust.

Soil Science and Agricultural Chemistry

(*a*) *Agricultural Chemistry*

(*i*) *Nitrogenous fertilisers.*—Further trials have confirmed that sodium chloride application increases the efficiency of inorganic fertilisers, as well as of bulky organic manures, and stimulates additional increase in the yield of crops. The effect appears to be specific for sodium since potassium failed to show any such response.

(*ii*) *Bone fertiliser.*—A chemical process, for disintegration of bones to yield a fine bonemeal, suitable for adoption on cottage or industrial scale has been worked out. Trials have shown that the product is as good as steamed bone meal in its effect on the growth of crops.

(*iii*) *Cowdung gas plant.*—The design of the plant has been modified so as to receive other organic waste materials as leaves, straw, farm and town sweepings. Production of gas from these has been estimated to be five times that obtained from dung alone.

(*b*) *Soil Survey*

(*i*) *Laterites.*—The study of laterites of Malabar was extended to include areas in Cochin and Travancore. These studies revealed that the so-called laterites of these States form a new group of soils, wherein thermal effects and climatic environment play the chief role.

(*ii*) *Alluvial soil.*—In order to study the morphology and genesis of alluvial soils in the arid and semi-arid regions, a type area comprising the States of Uttar Pradesh, part of Rajasthan and north Madhya Pradesh, between N. latitudes 76 and 82° and E. longitudes 26 an 82°, was selected. After a climatological analysis, the type area was provisionally divided into three regions. The soils of West Uttar Pradesh are being studied, to start with.

(*c*) *Physical Chemistry*

(*i*) Work on the reclamation of the saline and alkali soils of the Pusa farm has been started after providing drainage by means of open drains. The four electrode method of measuring soil resistivity in the field has been introduced for the quick location of the water table and impervious layers in the subsoil, information on which was required for the proper placing of the drains and for soil reclamation.

(*ii*) The inherently fertile plots of the Agronomy Division were found to have a higher content of Tuylins group I clay-humus complexes, as compared to the less fertile ones. Work is in progress on the agricultural practices necessary to raise the clay-humus complexes in the soil.

(*iii*) The strong interaction between illitic and montmorillonitic clays observed earlier has been confirmed by measurements on electrical conductivity and exchange-acidity of these clay-minerals and their mixtures.

(*iv*) Besides having higher electrical conductivity in the leaf juices, the frost resistant varieties of *arhar* were found to be more hydrophillic than the susceptible ones.

(*d*) *Organic Chemistry*

(*i*) *Pesticides.*—Indian turpentine oil forms a raw material for the production of terpene ethers and alcohols, used in insecticides and various other industries. With a view to explore suitable raw materials various turpentines have been tested. It has been found that besides the variations in the relative percentages of the constituents due to source and season of tapping, variations are also effected by the processes of distillation, as employed by various manufacturers of rosin and turpentine. Through the agency of the National Research Development Corporation, collaborative pilot plant investigations are under way at the Shri Ram Institute for Industrial Research for the production of terpene ethers and alcohols-synthetic pine oil.

(*ii*) A ketone, isomeric with camphor, obtained by the oxidative degradation of longifolene, has been found to possess fungicidal properties and is toxic against mycelium as well as spores.

(*e*) *Physics*

Methods for the estimation of zinc, polarographically, and iron, using spectrophotometer, in plant and soils have been standardised and are being used for routine estimation of these elements in citrus leaves.

An-x ray diffraction unit and an electron microscope have been obtained for the study of clay minerals, plant tissues and viruses. Work was taken up on the control of health hazard from the use of radio-active isotopes in the research projects in progress in the various Divisions of the Institute.

(*f*) *Biochemistry*

(*i*) *Foliar application of urea.*—Experiments conducted in the field have confirmed the earlier finding that foliar application of dilute solutions of urea at the time of flowering significantly increases the yield and protein content of wheat grains. The content of nicotinic acid in the grain has also been found to have increased considerably by such application of urea.

(*ii*) *Mechanism of utilization of urea-nitrogen.*—In order to find out the mechanism by which urea-nitrogen is utilized in the plant, when sprayed on the leaves, the presence of urease in wheat leaves was studied. Urease was found to be present in these leaves. A partially purified enzyme was prepared from this source and its kinetics was studied.

(*iii*) *Micro-element fertilisers.*—Experiments carried out in pots to study the effect of foliar application of copper, manganese, zinc, magnesium and their combinations on wheat mostly confirmed the results of the field experiment reported earlier. The increase in grain yield observed on account of these sprays was found to be primarily due to the increase in the number of fertile spikelets in the ear. It was found that spraying of all these elements was conducive to a greater synthesis of protein in grains. It was also found to have increased the phosphorus and calcium content of the grains.

(*iv*) *Food value of pulses.*—The biological value of proteins in *arhar* was found to have increased significantly with supplementation of methionine and lysine but not by threonine and tryptophane, while that of *urid* increased with methionine alone. Supplementation of vitamin B_{12} also significantly improved the biological value of *arhar* proteins. The excretion of amino acids in the urine of rats was found to be maximum with supplementation of methionine followed by that of lysine, threonine, tryptophane and vitamin B_{12} in the case of *arhar*.

Pancreatic digestion of plant proteins in gram, *mung*, *lentil*, *arhar* and pea was compared with that of casein and meat. The release of amino acids from pulses, casein and meat was found to be 41, 57 and 87 per cent, respectively. The number of enzymatically released amino acids, estimated chromatographically, was more in animal proteins as compared to those in plant proteins.

(*g*) *Microbiology*

(*i*) A strain of phosphobacteria (A24) from Czechoslovakia was observed to bring into-solution phosphorus from insoluble organic and inorganic phosphates when supplied with suitable forms of combined nitrogen. A similar organism was isolated from the glands of *Cassia occidentalis*. A large number of soil organisms, particularly the ammonifiers, was observed to be capable of solubilising insoluble phosphates ordinarily present in the soil.

(*h*) *Soil Testing*

A chain of Soil Testing Laboratories has been established at fourteen locations beside, New Delhi *viz*., Calcutta, Hyderabad, Orissa, Trivandrum, Nagpur, Ludhiana, Poona, Simlas Bangalore, Nabha, Gwalior, Sabour and Coimbatore.

Production demonstration trials were successfully undertaken in the *rabi* season on wheat crop with the object of demonstrating to farmers of Delhi State the benefit of using fertilisers for increased crop production. The mobile soil testing van started functioning in the Delhi Intensive Cultivation Scheme, operated by the Institute for advising the farmers in their fields.

(*i*) *Radio-tracer investigations in soils and fertilisers*

By using radio-active phosphorus (P^{32}) in soil fertility investigations for the determination of phosphorus fertility status of soils in India it has been found that at least 50 per cent of the country's soils could profitably respond to phosphorus fertilisation. Using soils from the various parts of the country, a modified soil test for phosphorus has been developed which is both quick and accurate. In a field experiment with radio-active superphosphate, it has been observed that paddy cultivation under Delhi condition does not benefit from deep placement of the phosphatic fertiliser over the usual broadcast or surface application. By radio-auto-graphic technique this movement of phosphorus was found to be very restricted and even under flooded condition the applied phosphorus moved down from the surface by about an inch.

(*j*) *Cartography*

(*i*) A working guide has been prepared for the coordination of work done under the All India Soil Survey Schemes in the different soil zones, with a view to give a geographical basis to such surveys.

(*ii*) The working out of the Basic Soil Regions in India has been undertaken.

(*k*) *All India Soil Survey*

In the Alluvial Soil Region, field studies of soils have been carried out in the N.E.S. blocks at Nawanshahr in Jullundur Dist., Punjab, and at Sohowal in Satna Dist., Madhya Pradesh The soils in the two blocks, covering about 150 and 200 sq. miles, have been classified.

Entomology

The research programme covered both the fundamental and applied aspects of investigations on the biology and control of insect pests of agricultural crops and orchard trees. Attention was concentrated on six major aspects of entomological research, namely, taxonomy, parasitology, physiology, ecology, toxicology and investigations with the help of radio-active isotopes.

(*a*) *Insect taxonomy*

Taxonomic researches have been continued on curculionid weevils, lady-bird beetles, dragon flies and parasitic wasps. Detailed studies on plant lice, tobacco beetle, tree hoppers and family of chalcid wasps were also taken up. Studies on the genitalia of Indian wasps have not only indicated that the separation of three sub-families recognised so far on other characters only is really based on firm grounds but also that they show a gradual gradation of characters from another closely related sub-family. Studies on the terminalia of the lady beetles were completed and the affinities of the various groups within the family were worked out.

(*b*) *Insect parasitology*

Work relating to the survey and collection of new and important parasites of important crops pests was continued; the parasites thus collected are being classified and information regarding the name and family of the hosts and the host plants and the localities from where these parasites were collected have been included in the list. Studies in the effect of nutrition on the longevity, fecundity and sex-ratio of a larval parasitic wasp were continued by feeding the host on various synthetic diets; adults reared on the host fed with crushed *jowar*, mixed with nicotinic acid, at the rate of 10-20 micro grams per gram of *jowar*, gave the best results. Studies on the host larval growth showed that development was most satisfactory when they are fed with crushed *jowar* mixed with groundnut in a 4 : 1 ratio. In the case of a chalcid wasp parasitic on *pyrilla* eggs, absence of food was found not to affect significantly the fecundity of the parasite. Superparasitism was found to be absent in this wasp.

(*c*) *Ecology and toxicology*

For testing the efficiency of the biometer constructed for the chalcid parasite (*Trichogramma*), the rate of development of this insect under constant and fluctuating temperatures wadetermined during different seasons. Bioclimatic fluctuations in the population of the painted bug were continuously recorded. Two generations of the pest were successfully reared on soaked mustard seeds. Experiments designed to evolve a spraying schedule against mustard aphid showed that, on the basis of the average yield from the different treatments, the relative efficacy of the different insecticides was in the following order: Parathion, *gamma* BHS, pestox, basudin, dieldrin, nicotine sulphate. The overall effect of DDT sprays on the population of pests in the cotton crop indicated that, after the fifth spraying with DDT suspension at the rate of 1 lb. per acre, the populations of jassid, thrips, white fly and aphid were reduced by 100%, 96·2% and 70·8% respectively while that of pink boll worm and mite increased by 66·6% and 40·75% respectively. The relative solubility of DDT, BHC, dieldrin and endrin crystal suspensions in the films of cuticular wax of the flour beetle was found to be positively correlated with the relative toxicity of these insecticides to this pest. Bioassay studies showed endrin emulsion to be most toxic to the castor hairy caterpillar and parathion most toxic to mustard aphid. In the studies on the comparative toxicity of fumigants to the flour beetle in wheat kept in bins, carbon tetrachloride was found to be better than either EDCT mixture or ethylene dichloride. Carbon tetrachloride also gave quite satisfactory results in bulk fumigation. In tests with pyrethrum used as a spray against 'Khapra' grubs, the synergistic effect of piperonyl butoxide was confirmed for both kerosene oil and petroleum ether used as solvent for the insecticide. Experiments on the control of termites in sugarcane by treating the soil with various organic insecticides gave the best results with DDT from the point of view of yield. Preliminary exploration of toxicity hazards in the use of modern organic insecticides was started.

Work on the biological testing and certification of insecticides was taken up. Experiments designed to effect an ecological control of insect pests of storage were carried out with special reference to pit storage.

Research work on the raising of pedigree queens of honey bees has been started.

(*d*) *Insect physiology*

Physiological studies were in progress on the effect of aqueous solution of nickel chloride on a few insects that were pretreated with an alkali. It was observed that eggs of a fruit fly, a parasite, the rice moth and the housefly could be killed by such treatments. Studies have been also in progress on the rearing of insect pests and parasites on artificial diets and a few have been successfully reared up to the adult stage. Vitamin requirements of some of the beetles associated with stored grains have been worked out. For the eradication of symbiotic micro-organisms in the saw toothed beetle, eggs of this pest were exposed to ultraviolet rays and positive results were obtained.

(*e*) *Investigations with the help of radio-active isotopes*

Preliminary observations have shown that at lower levels of radio-activity there was an increase in the fecundity of a beneficial larval parasite. Studies were also made regarding the translocation of a systemic insecticide in cotton plants and the uptake of the poison by red cotton bug.

Mycology & Plant Pathology

(a) *Diseases of wheat*

(i) *Rust* : Four hundred and thirteen samples of black, brown and yellow rust of wheat were analysed and races 15, 17, 21, 34, 40, 42 and 42-B of black rust, races 10, 11, 20, 26, 63, 70, 77, 106, 107 and 108 of brown rust and races 13, 19, 20, 31, A and G of yellow rust were met with; indications of a new race of brown rust resembling race 162 have been obtained. Race 70 of brown rust reported from the Punjab last year was met with again this year from the same State. Race 42-B, 21 and 40 of black rust of wheat, 20 and 63 of brown rust, and races 19 and A of yellow rust were predominant.

Thirty-four grass species belonging to 16 genera were tested against the three rusts of wheat and black rust of oats. Four species of *Aegilops* were found to be susceptible to the three rusts of wheat, but they were resistant to black rust of oats; *Phalaris canarensis* and *Avena glauca* were susceptible to black rust of oats only. Natural infection of black and yellow rust of wheat was observed on four species of *Agropyron* and fourteen species of *Aegilops*.

Survey of the upper Simla Hills showed that the wheat rusts could survive during the summer months at various localities.

Test of the adult plants of the variety, Ridley, revealed that it shows susceptibility to most of the races of black rust though it is resistant to the same races in the seedling stage.

In all 17,654 plants of wheat varieties, their crosses and progenies were tested in the seedling stage either with individual wheat rust races or a mixture of the races and no variety was found to be resistant to all the individual races of black and brown rusts. As regards yellow rust, the wheat variety-P. D. 14 selected at Wellington, was found to be resistant to all the races, except race 31.

Detailed studies of black rust races have revealed some differences in the uredospore colour, pustule nature and incubation period. The incubation period was found to be different for different races at the same temperature. A combination of races 21 and 40 of black rust in equal proportions has been maintained on the wheat variety, *Agra Local*, for five successive generations without any appreciable change in the frequency of the two components. There were, however, marked differences in frequency with the change in variety.

(ii) *Loose Smut* : Out of the 57 varieties tested at Delhi, 35 remained free from smut infection. Amongst the smut-free varieties, E. 1913, H.D.–(52)-46, H.D.–(52)-67, H.D.–(52)-70 and H. D. –(52)–71, had remained free from smut infection during the last three years tests. In some of the susceptible varieties infection as high as 81 to 100% was obtained.

(iii) *Karnal Bunt* : Of the 95 wheat varieties inoculated for varietal resistance test at Karnal under field conditions with sporidial suspension, 42 varieties remained free from bunt infection. Amongst the susceptible varieties, N. P. 165 and NP 720 have shown as high as 86 and 80% infection, respectively, on ear-basis. The maximum infection obtained in individual ears on grain-basis was 92% in the variety H. D.–(53)–142.

Infection was considerably higher when the ears were inoculated in the boot-stage than in the anthesis stage. Higher infection was also obtained when the inoculations (boot-stage) were made in early February than in late February.

Hill Bunt : Data on the varietal resistance tests with 55 varieties carried out at Simla this year are being analysed. Five varieties, namely, E. 56, E. 192, E. 201, E. 740 and E. 2327 appear to be resistant.

(b) *Barley*

(i) *Rust* : Twenty-six samples of black and yellow rust were analysed and races 21, 34, 40, 42, and 42-B of black rust and 13, 19, 20, 31 and G of yellow rust were met with. In connection with the seedling resistance tests, 654 barley plants were tested against the two rusts and the varieties, NP 4 and Proctor, were found to be resistant to all the races of yellow rust.

Puccinia hordei, hitherto considered to be of rare occurrence in India, was observed at several places in Madras, U. P. and Delhi State. Two samples of *Puccinia hordei*, which had shown clear differences in rust reaction on some local barley varieties did not show any difference in reaction on the standard differentials.

(ii) *Smut* : Out of the 58 barley varieties inoculated last year with loose smut, the varieties-B. 17, B. 146, B. 164, B. 231, B. 237, NP 2 and NP 7 did not show any smut infection.

(c) *Sugarcane*

(i) *Red Rot* : Twenty-five isolates of the red rot fungus obtained from different localities and various cane varieties were tested on ten standard cane varieties, but no evidence of physiologic specificity was obtained in any of the isolates and the cane varieties tested. In the varietal resistance tests, 178 important and promising cane varieties were tested by the plug method and 91 by the nodal infection method. Four varieties, namely, Co. 939, Co. 966, Co. 1046 and B. O. 30, in the former test and one variety (Co. 1078) in the latter, reacted as resistant. In the experiments to determine the effect of mixed inoculation on red rot infection it was observed that the mixture of light and dark type isolates gave greater infection, in some varieties than the individual strains or mixture of two light or two dark type isolates. The amount of inoculum, however, does not appear to have any effect on the amount of infection.

(ii) *Smut* : In the varietal resistance tests carried out with 170 cane varieties, 10 varieties, namely, Co. 1005, Co. 1022, Co. 1023, Co. 1026, Co. 1027, Co. 1034, Co. 1134, Co. 1143, Co. 1147 and B. O. 28, gave less than 5% infection and may, therefore, be considered as resistant. The maximum infection obtained in these tests was 90%.

(d) *Linseed*

Rust : Seventy-eight rust samples obtained from different parts of the country were analysed and all the five Indian races of *Melampsora lini* were met with. In the seedling resistance tests, ten varieties, namely, E. C. 6163, E.C.8702, E.C.8703, E.C.8704, E.C.8705, E.C.9964, E.C. 9969, E.C.9971, E.C.9723 and E. C. 10663, were found resistant to all the five races of linseed rust under glasshouse conditions. In the adult resistance tests, 66 out of 140 varieties proved resistant.

(e) *Pigeon pea*

Wilt : Of the 20 varieties tested for their resistance to the disease, six varieties (NP41, N.P.W.R. 15, S. 34, S. 55, S.83 and S. 86) showed less than 10% infection whereas the maximum infection obtained was 73.3%.

(f) *Maize rust*

Indications of the existence of at least two physiologic races of the rust, as judged by their reaction on the maize variety, R. 88, have been obtained.

(g) *Antibiosis*

Increased amount of the antibiotic was produced by *Bacillus subtilis* in sterilized soil supplemented either with glucose and asparagin or glucose and roots of some leguminous plants. The wilt disease of pigeon-pea was considerably reduced in such soils. Further work in this direction is in progress. Attempts were being made to isolate the antibiotic and study its properties. Chromatograms could be successfully developed on Whatman No. 1 filter paper using Isopropyl Alcohol-Acid-Water (70 : 2 : 28) as solvent system. The antibiotic could be eluted out with N-Butyl alcohol.

(h) *Physiology of Fungi*

Inoculation tests on sugarcane indicated that the light, highly sporulating isolate of *Colletotrichum falcatum* (Isolate No. 244) was more virulent than the dark, sparsely sporulating one (Isolate No. 78). Furthermore, it was observed that the two cane varieties, Co. 312 and Co. 647, showed considerable difference in the degree of their resistance to C. *falcatum*.

A dose of Brown's Synthetic Medium in advance of inoculation resulted in enhanced parasitic activity of the isolates. Apparently, the asparagin constituent of the medium was responsible for such reaction.

(i) *Effect of atomic radiations on fungi*

Effect of radioactive phosphorus and fast neutrons on *Colletotrichum falcatum* was investigated. Three distinct mutants have been picked up which have maintained their characteristics for a number of generations. One of the mutants shows morphological variations in shape and size of the spores; another is a biochemical mutant connected with vitamin synthesis and the third forms creamish white spore masses in culture instead of the usual pink masses of the parent cultures. Similarly, mutations in *Phycomyces blackesleeanus* have been induced with the help of P^{32}. The mutant cultures, in general, tended to be more pigmented or sterile, or produced dwarf but fertile sporangiophores.

(j) *Fungicides*

Laboratory experiments were conducted to test the comparative efficacy of twenty proprietary fungicidal preparations against seed-borne infection of stripe disease of barley and stem rot of jute. Agrosan GN 0.3%, Fusariol 0.18% and Agrosan 5W 0.15% of the seed weight effectively checked the growth of the stripe disease organism whereas N. I. Ceresan 0.4% Flit 406(0.4%)and Agrosan 5W 0.4% of seed-weight proved better against the stem rot fungus. In the comparative fungicidal trials in the field against Tikka disease of groundnut, Fytolan, Fungi Mar and Dithane Z.78 gave better results as judged by the disease incidence and yield.

The Aretan treatment of sugarcane setts at the time of planting showed about 23% increase in yield from the plots planted with setts treated with Aretan at the rate of 1 lb. in 10 gal. of water ("In and out dip" as compared to the untreated control).

A mixture of sulphasomidine and sulphaguandine supressed the rust pustule formation on the inoculated wheat seedlings which, however, could be initiated again by spraying the plants with folic acid.

k) *Bacterial and nematode diseases.*

A leaf spot disease of chilli has been shown to be caused by *Xanthomonas vesicatorium.* Comparative morphological, cultural and biochemical studies of thirty-three isolates of *X.Citri* (citrus canker organism) from different *Citrus* spp. did not reveal any difference in the isolates.

Thirteen root-knot diseases on various plant species, *e. g.*, *Abelmoschus esculentus*, *Luffa cylindrica*, *Momordica charantia*, *Digera arvensis*, *Celosia argentia*, *Solanum, melongena*, *Lycopersicon esculentum*, *Cuminum cyminum*, *Dolichos lablab*, *Nicotiana tabacum*, *Cucurbita moschata* and *Vigna sinensis* caused by species of *Meloidogyne* were recorded. Analysis of soil samples in connection with the survey of plant parasitic nematodes has led to the identification of thirteen nematode species.

(l) *Virus diseases*

Marble Disease of cherry, yellow mosaic of *Rubus ellipticus* and 'Chirke' disease of large cardamon were established to be of virus origin. A "die-back" disease of citrus has been transmitted by tissue-grafting to standard Sour Lemon, Sour Orange and Key-Lime producing symptoms typical of 'Tristeza' virus.

In the varietal resistance tests, six Indo-American cottons, *viz.*, (170 × Co. 2)-2(SF), (134 × Co. 2)-M-26(SF), 68 × (Exotic-3 × Acala 8), 68 × 22-(SF), B.C.-68 × 22 and Co. tom 23(SF), proved immune to the virus causing the small leaf disease. *Abelmoschus crinitus* and A. *manihot* were found to be immune to yellow vein mosaic virus of *bhindi*, whereas A. *angulosus* showed tolerant reaction. Grassy shoot of sugarcane was transmitted by the aphid, *Longunguis sacchari*, to sugarcane and *Sorghum vulgare*. Mosaic diseases of lettuce and soyabean were transmitted by juice inoculations and also through the seed obtained from diseased plants. *Aphis gossypii*, and an unidentified aphid collected from *Solanum nigrum* were found to be the vectors of lettuce mosaic while soyabeen mosaic was transmitted by four species of aphids, *e. g.*, *Aphis gossypii*, *A.*

laburni, *Myzus persicae*, and an unidentified cabbage aphid. *Myzus Persicae*, *Aphis laburni* and *Macrosiphoniella sanborni* were found to be the vectors of broad bean mosaic also. *Myzus persicae* and *Macrosiphum* sp. were found to be the additional vectors of chilli mosaic and papaya mosaic virus, respectively. Brinjal mosaic and little leaf virus were transmitted by a dodder sp. (*Cuscuta australis*). Sasamum phyllody virus was transmitted to *Cicer arietinum*, *Crotalaria lanceolata*, *C. medicaginea*, *C. retusa*, *Brassica campestris* var. *toria* and *B. campestris* var. *Sarson*. The virus is of the persistent type.

(m) *Systematic mycology*

Taxonomic studies on miscellaneous Indian fungi were continued. Two new genera, *Chonella* and *Koorchalomella*, twelve new species, and twenty new host records for the previously known species have been established during the period under report.

Agricultural Engineering

(a) *Development of a winnowing fan*

In order to overcome the difficulties caused to the farmers by the absence of good breeze after the threshing of grains, a winnowing fan with single sprocket and chain drive has been designed and developed by this Division. The fan can be easily worked at 300 R. P. M. and it costs approximately Rs. 65/-. Many other types of winnowing fans are available in different regions of the country and the fan designed by this Division was tried simultaneously with those from the States of Bombay, Bihar and Punjab and the results were found to be quite satisfactory. The fan was demonstrated in the villages, and it is expected that it will benefit the local farmers to a considerable extent. Practical field tests of the fan are being arranged.

(b) *Development of bullock-operated leveller*

A considerable time is wasted in levelling the fields after ploughing, due to want of an efficient levelling implement. A bullock-operated leveller has been designed and fabricated with a view to remove this difficulty. After a series of field tests, the implement has been made of 10 ft. length. It is very simple in construction and is made entirely of wood. The implement has been found to be quite satisfactory for levelling the uneven fields after ploughing. The implement is likely to be popular with the farmers. Arrangements for its more extensive trials are being made.

(c) *Improvement of Olpad Thresher*

The bullock-operated Olpad thresher, manufactured by M/s Cossul and Co., Kanpur, was tried and was found suitable for threshing wheat. It was however, observed that the *bhusa* produced by this thresher was of rough quality. In order to produce finer *bhusa*, the thresher was modified in this Division by increasing the number of discs in the machine. In the original Olpad thresher, 20 discs are set in three rows, but now two more discs have been added in each row, the total number of discs thus having been increased to 26. This modified thresher was tried in the villages simultaneously with one of the original design and it was found that besides producing finer *bhusa* it took much less time to thresh the same quantity of grain. The modified thresher is now being put to further extensive trials.

(d) *Development of a bullock-drawn seed drill*

Although many types of seed drills are available in the market, the ordinary farmers are not able to use them on account of their high prices, limited utility for sowing seeds, and complicated mechanism for adjustment, use and maintenance. In order to resolve these difficulties, work has been taken on hand to devise a cheap, simple and suitable seed drill for different types of seeds. A single-row experimental machine has been designed and fabricated. The results of the preliminary tests of this experimental model have been found to be promising. Some modifications to the seed box and the seed dropping mechanism are now being carried out. As soon as the laboratory tests are completed, the drill will be put to field trials.

Horticulture

Under the Second Five-Year Plan, the nucleus Section of Horticulture, which was set up in 1954 in the Division of Botany, was expanded in 1956 into a separate Division of Horticulture. Three Sections, *viz.*, Pomology, Vegetable Growing, and Fruit and Vegetable Preservation, are envisaged under this Division. Of these, the first two Sections started functioning during the year under report. The projects initiated include : standardisation of root stocks and of manurial practices in fruit trees, use of hormonal sprays, study of genetic variability and induction of polyploidy and mutations in fruit trees like guava, grapes, citrus, mango and other fruits. A comprehensive collection of superior germ-plasm in tree fruits is being built up.

3. GENERAL FEATURES OF THE REPORT

(i) *Land and buildings*

No land was acquired during the year. The following buildings were completed, though in certain of them electric connection has yet to be provided:—

1. Pot culture house in the Agronomy Division.
2. Extension to the Mycology, Agronomy and Botany Divisions.
3. Glass House in the Botany Division.
4. Double-storeyed residential quarters in the new area.
5. Virus Research Laboratory at Poona.
6. Proto-type Soil Testing Laboratory in the Chemistry Division.
7. Laboratory building and glass house at Wellington.

The following construction works were taken up during the year and are still in progress:—

1. Machine shed in the Entomology Division.
2. Green House in the Chemistry Division.
3. Museum for agricultural implements.
4. Workshop and office buildings of the Agricultural Engineering Division.
5. Assembly Hall.
6. Extension to Director's office.
7. Soil Survey Laboratory in the Chemistry Division.
8. Completion of fencing.
9. Open-surface well at Indore.

(ii) *Post-graduate training*

Out of a total of 259 applicants, ninety-one students were selected during the year for the regular post-graduate training in different subjects.

The Institute has established a full-fledged radiotracer laboratory. Finding that there is an increasing interest in the use of radioactive isotopes among the agricultural research workers all over the country, a three-month refresher course on the use of radioactive isotopes in agriculture was started at this Institute. The first course was held for three months from February, 1957. Nine candidates were imparted training.

Besides, thirty-one students were given short course training in the different Divisions.

Nine honorary research workers were working in the different Divisions during the year.

Three scholars, under the Ministry of Education and Scientific Research Scholarship Scheme, were admitted in the Entomology and Agronomy Divisions.

Three Senior Research Fellows of the Indian Council and Agricultural Research were admitted to the different Divisions.

Fifty students, who successfully completed their studies in the post-graduate course, and three departmental candidates, were awarded the Associateship Diploma of the Institute. A list of theses presented by them is given in Appendix II.

(iii) *Library*

The total number of publications received in the library, both by way of exchange and purchase was 3,418. Seventy-five new periodicals were added to the library during the year. Of the 6780 books issued out on loan during the year, 595 were sent to scientific workers in the States and Universities. The Reading Room was used by 15,444 visitors, who consulted 69,953 books. References to literature on various subjects were supplied to the Ministry of Food and Agriculture, the Indian Council of Agricultural Research, State Departments of Agriculture, Universities and to individual scientists. Some of the subjects on which lists of references were supplied were : tropical crops in India, irrigation, climbers and creepers, books and journals on plant protection and horticulture, references on specific crop plants of India, cattle in India, books on Indian agriculture, journals on general agriculture published in India and abroad, periodicals on agronomy, soil conservation, irrigation, manures and fertilizers and statistics.

(iv) *Advisory work*

Besides the advisory committees of the Ministry of Food and Agriculture, and of the Indian Council of Agricultural Research, including the commodity committees under the Ministry, the Director served on numerous other expert committees constituted by various scientific organisations in India.

The Institute attended, as in previous years, to a large number of requests for expert advice and help on agricultural matters both from official and non-official sources. The types of querries attended to are indicated below:—

Agronomy : Cultivation practices : cereals, vegetables, potato, sugarcane, lemon grass, turmeric, black pepper; growing and curing of tobacco; cultivation and utilisation of grasses and legumes for various purposes; use of paddy husk for manuring of paddy; information on trends in agricultural production in India; growing hubam clover as a mixed crop with wheat; use of chemical weedicides; information on manures and manurial practices and on water requirements of major crop plants; supply of seed and other planting material of improved varieties, including grasses and legumes.

Botany : Identification of plant material and supply of common and botanical names of plants; notes on N. P. varieties of crop plants and vegetables and their cultivation; information on hydroponics and on the role of atomic energy in plant breeding; supply of pure seed of improved N. P. varieties of field crops and vegetables.

Chemistry : Analysis of soils, manures and water samples; report on the soils of the Suratgarh Farm in Rajasthan; suitability of calcium ammonium nitrate on Indian soils ; survey of soils of some grazing areas in Kashmir for advising on mineral and trace-element deficiency.

Entomology : Identification of insect pests and advice on the control of insect pests and rodents; examination of samples of seed and other plant material for export or import and issue of health certificates thereupon.

Mycology and Plant Pathology : Identification of diseased specimens and of fungal and bacterial cultures; information on control of crop diseases; inspection of seed and other planting material for export or import and issue of health certificates thereupon.

Agricultural Engineering: Testing of agricultural implements; supply of information on, and working drawings of, improved agricultural implements.

Horticulture : Information on cultivation practices in fruit trees and ornamental flowers and on their methods of propagation; supply of planting material of improved varieties of fruit trees and ornamental flowers.

(v) *Research schemes*

Work on the following research schemes, financed by the Ministry of Agriculture, Government of India (including the Second Five-Year Plan schemes), Indian Council of Agricultural Research, Indian Central Oilseeds Committee and Indian Central Sugarcane Committee, was in progress in the different Divisions of the Institute during the year under report:—

No.	Title of scheme	Division	Sponsored by
1	Key Village Scheme	Agronomy	Ministry of Agriculture.
2	Project on irrigation investigations	Do.	Ministry of Agriculture (2nd Five-Year Plan).
3	Project for investigation on weed control . . .	Do.	Do.
4	Project for plant tissue test and spray-fertilisation investigations.	Do.	Do.
5	Scheme for collection of indigenous and exotic pasture grasses and legumes.	Do.	Indian Council of Agricultural Research.
6	Scheme for agronomcial studies on oilseeds crops .	Do.	Indian Central Oilseeds Committee.
7	Scheme for setting up Seed Testing Station . . .	Botany .	Ministry of Agriculture (2nd Five-Year Plan).
8	Scheme for studies on chapatee-making and baking qualities of Indian wheats.	Do.	Do.
9	Scheme for bunt control in wheat	Do.	Do.
10	Coordinated Wheat Rust Control Scheme (Botanical Portion).	Do.	Do.
11	Establishment of Plant Introduction and Exploration Organisation.	Do.	Do.
12	Establishment of Central Vegetable Breeding Sub-station, Katrain.	Do.	Do.
13	Scheme for the use of radioactive isotopes in cytogenetic studies.	Do.	Do.
14	Scheme for the establishment of a unit for embryo-culture work.	Do.	Do.
15	Coordinated Maize Breeding Scheme . .	Do.	Indian Council of Agricultural Research.
16	Coordinated scheme for the improvement of chillies .	Do.	Do.
17	Scheme for the improvement of essential oil yielding plants	Do.	Do.
18	Coordinated scheme for the improvement of musk-melon and water-melon.	Do.	Do.
19	Scheme for the improvement of pasture grasses and legumes.	Do.	Do.

No.	Title of scheme	Division	Sponsored by
20	Coordinated scheme for citrus die-back disease	Botany.	Indian Council of Agricultural Research.
21	Coordinated scheme for presoaking seeds in nutrient salts.	Do.	Do.
22	Scheme for the study of genetic variability in algae from the viewpoint of their use in agriculture.	Do.	Do.
23	Scheme for cytological studies on some oilseed crops	Do.	Indian Central Oilseeds Committee.
24	Scheme for physiological investigations on autotetraploids of some oilseed crops.	Do.	Do.
25	All-India Soil Survey Scheme	Chemistry	Ministry of Agriculture (2nd Five-Year Plan).
26	Scheme for working electron microscope	Do.	Do.
27	Radio-tracer investigations	Do.	Do.
28	Unit of physics	Do.	Do.
29	Cartography Laboratory and Soil Mapping	Do.	Do.
30	Scheme for the studies on chemical composition and nutritive value of wheat.	Do.	Indian Council of Agricultural Research.
31	Scheme for research for the examination of rapid methods of soil test for soil survey work.	Do.	Do.
32	Scheme for the collection of soil survey data in India	Do.	Do.
33	Scheme on foliar application of nutrient to crops	Do.	Do.
34	Scheme for the development of anti-oxidants for edible oils and fats.	Do.	Indian Central Oilseeds Committee.
35	Scheme regarding research on insect physiology	Entomology	Ministry of Agriculture (2nd Five-Year Plan).
36	Scheme for entomological investigations with the help of active isotopes.	Do.	Do.
37	Research scheme on Indian honey bee at the Botanical Sub-station, Pusa (Bihar).	Do.	Do.
38	Scheme for the stuyd of beneficial parasites of pests of agricultural crops.	Do.	Do.
39	Scheme for establishing a unit for storage pest ecology	Do.	Do.
40	Scheme regarding Unit for Biological Testing and Certification of Insecticides.	Do.	Do.
41	Scheme for setting up of Seed Testing Station	Do.	Do.
42	Termite Research Scheme	Do.	Indian Council of Agricultural Research.
43	Scheme for exploration of toxicity hazards in the use of modern insecticides against cattle and human beings.	Do.	Do.
44	Scheme on nutritional and biological studies on the insects of agricultural importance.	Do.	Do.

No.	Title of scheme	Division	Sponsored by
45	Coordinated Wheat Rust Control Scheme . . .	Mycology & Plant Pathology	Ministry of Agriculture (2nd Five-Year Plan).
46	Coordinated Plant Virus Disease Scheme . . .	Do.	Do.
47	Scheme for use of atomic energy in plant pathological research.	Do.	Do.
48	Scheme for the study of bacterial plant pathogens .	Do.	Do.
49	Scheme for testing of efficacy of fungicides . . .	Do.	Do.
50	Scheme for appraisal of losses due to plant diseases .	Do.	Do.
51	Scheme for setting up of seed testing station . . .	Do.	Do.
52	Coordinated Plant Virus Research Scheme, Eastern Zone.	Do.	Indian Council of Agricultural Research.
53	Scheme for the development of Herbarium Cryptogamae Indiae Orientalis.	Do.	Do.
54	Scheme for research on virus diseases of oilseed crops .	Do.	Indian Central Oilseeds Committee.
55	Linseed Rust Scheme	Do.	Do.
56	Scheme for research on the diseases of sugarcane . . .	Do.	Indian Central Sugarcane Committee.
57	Museum of Agricultural Implements	Agricultural Engineering	Ministry of Agriculture.
58	Survey of indigenous agricultural implements in common use in the country.	Do.	Indian Council of Agricultural Research.

(vi) *Collections and herbaria*

The foreign plant introduction and indigenous collection during the year numbered 2397 and 740 items respectively, bringing the total collection to over 17,000 items. Important among the introductions were in the case of wheat, maize, sorghum, cotton, linseed, vegetables including tomato, onion, cabbage, cauliflower, and ornamental flowers including roses and chrysanthemums.

Ninety-one specimens of insect species so far totally unrepresented or very poorly represented were added to the National Pusa Collection. In addition, a thousand other insect specimens have been locally collected and two hundred and fifty others procured from Sikkim and added to the general collection pending identification. The rearrangement of the main collection, according to the most recent trends in the taxonomy of the various families, has been taken up.

During the period under report, 96 fungal and bacterial cultures were added to the Indian Type Culture Collection in the Mycology Division, bringing the total number of cultures to 1,083. About 200 cultures were supplied to various scientific workers and research Institutions in the country and abroad. A consolidated list of the cultures maintained in the Collection is being prepared for publication. Detailed information regarding each culture is being entered in the Descriptive Forms. Studies on mineral oil and soil preservation of fungi were continued and out of the 87 cultures preserved in mineral oil, 76 were found viable after a period of about eight years. In all 1,223 mycological specimens (both Indian and Foreign) were added to the Mycological Herbarium during the year, bringing the total number of accessions to 25,408. Two hundred and thirty-six specimens, including some type specimens, as

also 18 coloured plates and photographs of important plant diseases were supplied to various Indian and foreign workers. The Exsicati set on the Indian Uredinales, Fascicle III, has been completed and is ready for distribution.

(vii) *Intensive Cultivation Scheme*

The agricultural development work in the 19 villages made appreciable progress. The total number of demonstrations carried out were 478. Out of this 128 were on fertilizers, 39 on green manuring of wheat and six on control of weeds by use of herbicides. The saturation of the villages with improved varieties approached 70% of the sown area under the various crops. The varieties in great demand were : wheat N. P. 718; barley N. P. 13; peas N. P. 29; gram N. P. 58 and *bajra* T. 55. The tomato variety, Pusa Ruby, gained much ground. Pest control measures were undertaken on a large scale on vegetables, fruit trees and field crops. 627 maunds of seed of various crops were given fungicidal seed dressing treatment. Fuel gas plants, installed in six villages, are becoming very popular. The total quantity of grains threshed with Olpad thresher and by tractor disc was 4996 maunds. Reclamation of saline and alkaline soils was taken up on a pilot basis in three villages. 1724 maunds of fertilizers were sold. The targets fixed for the land transformation programme in the village, Qamuruddin Nagar, were surpassed in all directions. A *Kisan Mela* was organised in these villages, in which the post-graduate students undergoing training, in this Institute, in agricultural extension also took an active part. These students also carried out, in these villages, some original investigations on methods of agricultural extension.

(viii) *Meetings and Conferences*

As usual, the Director, Heads of Divisions, and other officers of the Institute attended the meetings and conferences held under the auspices of the various Ministries of the Government of India, the Indian Council of Agricultural Research, various Commodity Committees etc. In September 1956, the Director attended the International Genetics Symposia held in Japan and presided over one of the sessions.

(ix) *Supply of pedigree seeds*

As in previous years, the demand for N. P. seeds, especially of wheat, from the different States was quite heavy. Since the area available for seed multiplication purposes was limited, the supply of seed fell short of the demand. The following quantities of pedigree N. P. seeds of different crops were supplied by the Institute :

Crop	Quantity of seed distributed
	(Mds.)
Wheat	2500.0
Oats	44.2
Barley	167.9
Maize	114.1
Paddy	133.0
Bajra	4.2
Gram	147.3
Arhar	23.7
Lentil	2.3
Mung	3.0

Crop	Quantity of seed distributed
Linseed	1.2
Sesamum	0.1
Safflower	1.1
Cotton	1.0
Hibiscus	1.0
Jute	1.5
Sunnhemp	15.1
Meth	3.0
Dhaincha	2.5
Berseem	27.2
Hubam clover	4.0
Guar	4.0
Tobacco	0.2
Vegetables (including peas and cowpea)	130.5
Sugarcane setts	200
Kudzu vine	4000 Crowns
Grasses and Legumes	395 samples

(x) *Visitors*

A large number of distinguished scientists and other dignitaries, both from India and abroad, visited the Institute; these included Members of Parliament and high officials of the Government of India and State Governments. Important among the visitors included: H. E. Dr. Jose Maza, President of the 10th Session of the General Assembly of the United Nations; His Majesty the King Emperor of Ethiopia; H. E. the President of Syria; H. H. the Maharaja of Sikkim; H. H. the Maharaja of Bharatpur; delegations of experts from China, Ethiopia, U. S. S. R., Czechoslovakia, Iran; Mr. Dean Rusk, President, Rockefeller Foundation; H. E. Mr. Josef Cyraniewiez, Prime Minister of Poland; H. E. Mr. Chou-en-Lai, Prime Minister of the Peoples Republic of China; H.E. the Prime Minister of Nepal; Mr. Ataur Rahman Khan, Chief Minister of East Pakistan; the Minister of Education, Finland; delegates from the U. S. A. under the International Farm Youth Exchange Programme; Dean Rummel of Ohio University; Dean Howard of Illinois University; Dr. A. H. Moseman of the Rockefeller Foundation, U. S. A.

Part II

REPORTS OF THE HEADS OF DIVISIONS FOR 1956-57

REPORT OF THE DIVISION OF AGRONOMY

(INCLUDING AGRICULTURAL RESEARCH SUBSTATION, KARNAL)

(Dr. P. C. Raheja)

I. *Season and Crops*

A summary of the meteorological observations is given below :—

Item / Month	Temperature				Humidity	Rainfall		Wind Velocity	Sunshine	Evaporation
	Mean Max. °C	Dep. from normal	Mean Min. °C	Dep. from normal	Relative humidity at 7 A.M. (Local) %	Rainfall in m.m.s.	Dep. from normal	Mean wind velocity in Kms/hour	Mean hours of bright sunshine	Mean evaporation in cms. per day. (U.S.A. Standard)
July, 1956 . .	33.6	—1.9	25.8	—1.3	84.2	148.08	—46.48	8.90	7.07	0.81
August, 1956 . .	32.6	—0.7	25.2	—1.0	84.9	200.66	+58.42	5.99	7.16	0.71
September, 1956 .	35.2	+1.5	24.4	+0.3	71.3	21.59	—95.25	8.61	8.62	0.97
October, 1956 .	28.6	—40	19.1	+1.6	90.1	270.26	+235.21	4.64	7.41	0.46
November, 1956 .	25.7	—2.2	9.1	—0.7	81.0	5.84	+4.57	3.61	9.54	0.38
December, 1956 .	21.8	—0.8	7.3	+1.1	85.7	0.00	—2.03	4.14	7.56	0.25
January, 1957 .	18.2	—2.1	6.9	+0.4	94.0	41.40	+21.84	7.20	6.03	0.18
February, 1957 . .	22.3	—1.0	4.4	—3.4	81.5	0.00	—17.78	5.01	9.90	0.38
March, 1957 . .	27.3	—2.0	12.3	—0.8	80.2	49.78	+27.68	4.60	7.86	0.53
April, 1957 . .	34.5	—1.9	17.7	—1.0	51.2	4.06	—58.68	8.05	9.60	1.12
May, 1957 . .	38.3	—2.1	22.1	—2.8	41.8	3.56	—7.11	8.77	10.32	1.27
June, 1957 . .	39.9	—0.4	25.9	—2.2	51.2	7.11	—24.13	9.77	9.31	1.35

Rainfall received during the year was 725·34 mm. which was 96·22 mm. above normal. Weather in July and August was favourable for sowing and growth of *kharif* crops. Droughty condition prevailed in September which necessitated irrigating the *kharif* crops. The crops grown under rainfed conditions received a serious set back and dried up. 270·26 mm. of late rains received in October adversely affected the standing *kharif* crops most of which were ready for harvest. *Rabi* cereal and legume grain crops were sown without presowing irrigation. Winter months were favourable for growth of crops. January rains were beneficial particularly to *rabi* crops grown under rain-fed conditions. A heavy hailstorm followed by a windstorm with a velocity of about 75 miles per hour caused widespread lodging and damage to the standing *rabi* crops, in particular wheat crop. Humid conditions prevailing in April and May interfered with harvesting and threshing operations. In June, conditions were favourable for threshing of *rabi* crops.

The yields of principal crops grown on the farm are given below :—

Crop	Area	1956-57 Average yield mds. per acre	1955-56 Average yield mds. per acre
Wheat	..	..	21.67
Oats	57.72 ac.	11.78	20.49
Peas	15.76 ac.	10.67	16.94
Gram	79.85 ac.	5.10	7.18
Berseem	25.9 Ac.	424.03	478.84
Maize (grain)	25.99 ac.	10.42	15.43
Sugarcane (Stripped)	7.64 ac.	588.97	582.75

II. *Research Projects*

The research programme of the Division progressed under the sections of (i) Soil Fertility ; (ii) Field Crops ; (iii) Vegetable and Commercial Crops ; (iv) Farm and Cattle ; and (v) Under Schemes on (a) Fertilizer Use, (b) Weed Control, (c) Irrigation Investigations and (d) Agricultural Extension. The experimental results are reported as under :—

1. Soil Fertility Section

(i) *Building up of soil fertility through organic manures and inorganic fertilizers with and without a legume in the rotations*

The rotations followed in the experiment are (a) *maize-wheat-maize-wheat;* and (b) *maize-wheat-maize-peas.* The third 2-year cycle of the rotation commenced in 1956-57 when maize and wheat were grown in both the series. In the cereal rotation, the response to F. Y. M., Castor Cake, NPK and NP on maize showed significant effects over control treatment. The yields varied from 11·15 mds. under the no manure to 17·77 mds. per acre with F. Y. M. in conjuction with 60 lb. N + 100 lb. P_2O_5 + 100 lb. K_2O. Maize results in the legume rotation were vitiated on account of very heavy rains. The low yields of wheat in both the series are attributed to hailstorm damage but the increases in yield due to NPK and NP treatments are significant over the control and the residual effects of organic manures.

(ii) *Building of soil fertility through organic manures and inorganic fertiliser with* bajra *and wheat in the cereal rotation*

The object of the experiment is to study the possibility of growing *bajra* and wheat in the same year in conjunction with heavy manuring under irrigated conditions.

Bajra yields after wheat and fallow were 5·73 and 5·51 mds. respectively and do not differ significantly. 20 tons F.Y.M. increased the yield significantly and an extra yield of 1·52 mds. per acre was obtained over the control (4·85 mds.). Yields for 0, 20 and 40 lb. N as ammonium sulphate were 5·07, 5·46 and 6·33 mds. respectively—the difference with 40 lb. N per acre being significant over control. Wheat after fallow gave significantly higher yield (13·8 mds./acre) than wheat after *bajra* (11·8 mds/acre). F.Y.M. applied to wheat at 5, 10 and 20 tons per acre yielded significantly higher (13·7, 15·6 and 17·0 mds./acre respectively) than the control (7·1 mds./acre). The differences among the nitrogen levels are significant, the yields under 0, 20 and 40 lb. N as ammonium sulphate being 9·3, 12·9 and 16·2 mds. per acre respectively.

(iii) *Building up of soil fertility through organic manures including green manure and inorganic fertilizers*

This project was started in 1950-51 to evaluate the direct effect of organic manures alone and in combination with inorganic fertilizers on wheat and the residual effect on maize and wheat in *wheat-maize-wheat* rotation. Fourth cycle of the rotation commenced during the year under report wheat yields are given below:—

Treatment/acre I. Organic manures	Wheat yield Mds./acre	II. Inorganic fertilizers	Wheat yield Mds./acre
A. Control	12.99	1. Control	13.48
B. 'Guar' green manure	16.32	2. 40 lb. N	15.49
C. Castor Cake at 60 lb. N	16.10	3. 80 lb. P_2O_5	14.48
D. F.Y.M.	14.69	4. 40 lb. N+80 lb. P_2O_5	15.59
S. Em	+0.37	5. 40 lb N+80 lb. P_2O_5 +40 lb. K_2O	16.08
C. D. at 5%	1.91	S. Em.	+0.30
		C.D. at 5% level	0.83

Yields increased significantly with green manure and castor cake at 60 lb. N treatment over control. Top dressing 40 lb. N/acre increased the yield significantly by 2·0 mds. over the control. Additions of phosphate and or potash showed no further increase in yield.

(iv) *Effect of low doses of phosphate on berseem and after effects on wheat*

Third crop of berseem in the third cycle of the rotation *Berseem-Cowpea* (3 years) *fallow* or *cowpea—wheat* (3 years) was grown during *rabi* season. Cowpea was grown on residues of the last years' fertilized berseem crop. Yield results of cowpea green fodder and of berseem green fodder and seed are given below :—

Treatment per acre	Yield in mds./acre		
	Cowpea	Berseem	
		fodder	seed
A. F. Y. M. at 16 lb. P_2O_5	93.0	164.76	2.34
B. F.Y.M. at 32 lb. P_2O_5	118.2	354.26	3.70
C. F.Y.M. at 64 lb. P_2O_5	126.6	403.54	4.22
D. Super at 16 lb. P_2O_5	108.7	220.58	3.38
E. Super at 32 lb. P_2O_5	101.9	281.63	4.08
F. Super at 64 lb. P_2O_5	129.4	441.91	5.04
G. Super at 8 lb. P_2O_5+ F.Y.M. 8 lb. P_2O_5	100.8	215.26	2.69
H. Super at 8 lb. P_2O_5+ F.Y.M. 24 lb. P_2O_5	124.9	319.34	3.97
I. Super at 8 lb. P_2O_5+ F.Y.M. 56 lb. P_2O_5	140.6	479.44	4.22
J. F. Y. M. at 8 lb. P_2O_5 +super 24 lb. P_2O_5	118.7	322.98	4.06

Treatment per acre	Yield in mds./acre		
	Cowpea	Berseem	
		fodder	seeds
K. F.Y.M. at 8 lb. P_2O_5 +super 56 lb. P_2O_5	129.4	414.09	4.17
L. no manure	88.5	95.21	0.94
M. Fallow in berseem season	127.1	..	..
S. E.m.	+7.61	+29.30	+0.37
C.D. at 5% level	21.6	83.08	1.05

Unlike the results obtained in the past, the residual effect of phosphate on cowpea is significant. This may be due to the commulative effect of phosphate applied during the preceding years. The highest yield was obtained with 64 lb. P_2O_5 per acre. The results with berseem correspond to previous years. The yields of green fodder and seed increased significantly with the increasing levels of P_2O_5. Highest yields were obtained with 64 lb. P_2O_5 applied as F. Y. M. and super, singly or in combination

(v) *Effect of phosphate with and without potash and/or nitrogen on berseem and after effects on maize, cotton and wheat*

The experiment is being conducted in two series (a) *berseem* (fertilized)–*maize*—*berseem* (fertilized)–*Cotton-wheat ;* and (b) *Berseem* (fertilized)–*maize-berseem-cotton-wheat.* Unfertilized cotton and wheat were grown in both the series. The yields of cotton due to residual effects of fertilizers applied to berseem were highly significant over the control in both the series.

(vi) *Phosphate fertilization of legumes under rain-fed conditions*

17 *kharif* and *rabi* legumes were grown in an observation plot under rain-fed conditions to study the response to phosphate application. The results indicate that *guar*, cowpeas, *arhar*, *senji*, hubam clover and lucerne indicated higher yields with phosphate fertilization over no phosphate treatment.

(vii) *Effect of phosphobacterin inoculation of berseem seed on yield and P_2O_5 availability*

This project was carried out in collaboration with Chemistry Division. Berseem seed inoculated with phosphobacterin culture from U. S. S. R. was sown and fertilized with P_2O_5 at 60 lb. per acre as bonemeal, rock phosphate and superphosphate. Uninoculated berseem seed was sown under the same fertilizer treatments for comparison. The results indicate that phosphobacterin inoculation of berseem seed alone (401·89 mds./acre) and in conjuction with bonemeal and rock phosphate brought about increases in yield varying from 32·38 to 52·73 mds. per acre over the corresponding treatments of uninoculated seed. The experiment is being repeated next season for confirmation of the results.

(viii) *Comparative effect of different systems of rotations*

There are ten rotations of different intensities including fallow and green manure which have completed 6 years. Different rotations indicated significant differences in yields of potato, maize and sugarcane crops. The yields of potato in *G.M-wheat-fallow-potato-sugarcane* (331·12 mds./acre) and *maize-potato-sugarcane* (317·03 mds./acre) rotations are significantly higher than the rotation : *G.M.-potato-maize-peas* (244·31 mds./acre). Maize yields in rotations where it follows potatoes (16·48 mds./acre), sugarcane (15·85 mds./acre) and peas (15·20 mds./acre) are significantly higher than where it follows wheat (12·00 mds./acre) Sugarcane yielded (813·20 mds./acre) significantly higher in rotation : *G.M.-wheat-fallow-potato-sugarcane* than in rotations : *maize—potato-sugarcane* (667·17 mds./acre) and *fallow-wheat-cotton-fallow-sugarcane* (661·95 mds./acre). The data of the first cycle of the rotation are being compiled for publication.

(ix) *Hubam clover as mixed crop in wheat-maize cereal rotation*

This experiment was started in *rabi* 1955-56. Maize crop in *kharif*, 1956 failed due to heavy late rains. The results obtained with wheat in 1956-57 are given below :—

Treatment per acre	Yield of wheat mds/acre
A. Wheat—fallow; no manure	14.03
B. Wheat—maize; 40 lb. N to wheat	14.41
C. Wheat—maize: 40 lb. N to maize	16.94
D. Wheat—maize: 40 lb. N to each crop	18.23
E. Wheat+clover for fodder & G.M.—Maize : no manure	9.08
F. Wheat+clover for maize: 40 lb. N to maize	7.65
G. Wheat+clover for maize: 80 lb. P_2O_5 to clover	8.80
H. Wheat+clover for G.M. only—maize: no manure	10.83
I. Wheat+clover for maize: 40 lb. N to maize	7.91
J. Wheat+clover for maize: 80 lb. P_2O_5 to clover	12.01
K. Hubam clover G.M.—maize: no manure	..
L. Wheat—sannhemp G.M.: no manure	15.66
'F' test	Sig. 1%
S. Em.	± 1.87
C.D. (5%)	5.40

The highest yield of wheat (18·23 mds./acre) is obtained where maize and wheat received 40 lb. N dose each in the rotation. The second best treatment is wheat green manured with sannhemp (15·66 mds./acre) closely followed by wheat fertilized with N following unfertilized maize crop (14·41 mds./acre) and wheat after fallow (14·03 mds./acre). The effect of the preceding hubam clover on wheat is no evident. The yields vary from 7·65 mds. to 10·83 mds. per acre under different treatments growing hubam clover as a mixed crop for green manuring or for both fodder and green manuring.

2. Field Crop Section

(i) *Response curve of nitrogen with N. P. wheat varieties*

This was the second year of the experiment. The results showed that wheat N.P. 792 and N.P. 718 were equal (13·23 and 12·14 mds. per acre) in grain yield and significantly superior to N.P. 710 (9·51 mds./acre). Of the fertilizer treatments 40 lbs. N gave significantly higher yield (12·84 mds/acre) than the control, 20 lb. N or 60 lb. P_2O_5 per acre (9·43, 8·49 and 11·19 mds. per acre).

(ii) *Effect of 'soil need' fertilizer on wheat N.P. 710 and maize N.P. 2*

This was the third year of the trial and the 'soil need' imported complete fertilize (NPK) was tested against equivalent doses of N, NP and NPK, applied as ammonium sulphate, superphosphate and potassium sulphate. Unlike the last two years, d ifferences due to fertilizer

treatments over the control were significant. Highest yield of wheat was obtained under 'soil need' fertilizer (17·62 mds. per acre) which was significantly superior to NPK (14·12 mds./acre). The yields under N, NP and the control were 16·15, 14·73 and 8·00 mds. per acre respectively.

(*iii*) *Optimum time of application of F. Y. M. to wheat N.P.* 710.

Time of application of F. Y. M. *viz.*, three months, two months, one month and one week before sowing wheat, did not show significant effect on wheat (8·6 to 9·5 mds./acre). The doses of F. Y. M. at 2·5, 5 and 10 tons per acre also did not show significant differential response. The effect of nitrogen as ammonium sulphate at 10 lb. N per acre gave significantly extra yield of 2·3 mds. per acre over the control (7·60 mds./acre).

(*iv*) *Fertilizer value of dicalcium phosphate on maize and wheat.*

The experiment was conducted in collaboration with Chemistry Division. The treatments were 40 lb,. No. 40 lb. N + P as super (80 lb. P_2O_5) and 40 lb.N + P as dicalcium phosphate(80 lb. P_2O_5). Nitrogen dicalcium phosphate and superphosphate gave extra responses of 1·7 and 2·38 mds./acre respectively. The difference was significant.

(*v*) *Response of wheat varieties to levels of nitrogen and irrigation*

This was the first year of the project. A new durum variety of wheat, Hy. 52-(66) was compared with new varieties of vulgare wheat, N.P. 797 and N.P. 718 under varying conditions of soil fertility and moisture. The results are summarised below :—

Varieties	Yield mds./acre	Nitrogen levels	Yield mds./acre	No. of irrigation	Yield mds./acre
Hy. 52-(66)	18.70	Nil	15.06	One	17.07
N.P. 718	16.99	20 lb.	16.77	Two	17.53
N.P. 797	15.27	40 lb.	19.14	Three	16.36
S.E.M.	±0.68	S.E.m.	±0.68	S.E.m.	±0.68
C.D. at 5%	1.99	C.D. at 5%	1.99	..	..

Variety Hy-52(66) yielded significantly higher than N.P. 797 and the increase over N.P. 718 was not significant. 20 lb. N produced an extra yield of 1·7 mds. per acre which is not significant. Response due to 40 lb. N over the control was 4 mds. per acre which was highly significant. Irrigation levels do not show significant differential responses.

(*vi*) *Optimum seed rate, spacing and date of sowing for wheat varieties NP.* 710 *and N.P.* 718.

Seed rates at 50, 70 and 90 lbs. per acre and spacing between rows at 6″, 9″ and 12″ showed no significant differential response. The yields varied from 17·3 to 17·8 mds. per acre for seed rates and from 17·3 to 18·03 mds. per acre for spacings. Sowing on 25th October yielded the highest (21·1 mds./acre) followed by 12th November (17·2 mds./acre) and 1st December (14·5 mds./acre) sowings. Earlier sowings increased yields and were significantly superior to late sowings.

(*vii*) *Spacing*-cum-*varietal trial on arhar.*

The project was started in *kharif* 1956 in collaboration with Botany Division. The object of the trial is to study the performance of newly evolved wilt resistant varieties at the I. A. R. I., New Delhi as compared to varieties from the States. The highest yield was obtained from

variety F(52) from Bombay (18·0 mds./acre) but the differences in yield over newly evolved varieties at I. A. R. I, *viz.* N.P. (WR) 41 (16·7 mds. per acre); NP (WR) 38 (16·1 mds./acre); NP(WR) 42 (16·0 mds./acre); NP(WR) 15 (14·6 mds./acre); NP(WR) 40 (14·8 mds./acre) and U. P. T. 105 (15·68 mds./acre) are not significant. Row spacings varying from 2½ ft. to 4½ ft. showed no significant difference in yield.

(*viii*) *Varietal trial with wheat.*

Twenty three N.P. varieties of wheat were tested together with Punjab C. 591. The three high yielding varieties were N.P. 798, N.P. 775 and N.P. 799 (19·7, 18·9 and 18·3 mds/. acre) respectively. Last year, the first three places were occupied by N.P. 770, N.P. 111 and N.P 775. Year before last, the order of merit was N.P. 779, N.P. 797 and Pb. C. 591. The trend has, therefore, not been consistant.

(*ix*) *Fertilizer-cum-cutting trials with Rhodes and Blue panic Grasses.*

This is the second year of the trial of which the results are given below :—

Particulars	Yield of grass fodder in mds./acre.						
	Doses of nitrogen lb./acre				Interval of cutting in days.		
	0	40	80	120	20	30	40
1. Rhodes grass . .	123.49	145·13	208.45	245.64	176.68	179.09	186.21
'F' value		significant			not significant.		
S.E.m.		±6.20			±5.22		
C.D. at 5% . . .		17.7					
2. Blue panic . . .	236.21	284.75	374.82	460.34	321.82	343.25	352.12
'F' value		significant			not significant.		
S.E.m.		‡17.20			±20.17		
C.D.at 5% . . .		59.16			..		

The nitrogen doses significantly increased the outturn of both the grasses. With increasing doses 0, 40, 80 and 120 lb. N per acre, the yields increased significantly (123·5 to 245·6 mds./acre for Blue Panic). 20, 30 and 40 days intervals between cuttings showed no significant differences.

(*x*) *Grass Land Improvement Scheme* (*I. C. A. R.*).

Seed samples of 166 grasses and legumes, collected from different sources were tested. Grasses and legumes that showed promise in the preliminary trials are : *Brachiaria mutica* (A-2996), *Dichanthium caricosum* (A-2976), *Panicum virgatum* (A-2535), *Pennisetum ciliaris* (A-2814), *Pueraria Spp.*, *Desmodium tartuosum* and *Pisum arvense* (A-3047). Under rain-fed conditions, *Chloris gayana* (giant Rhodes) and *Urochloa mosambiciensis* gave significantly higher yields of forage (422·5 and 410·6 mds./acre) than other grasses. Lowest yields were obtained from *Panicum* types (208·6 to 228·7 mds./acre).

Setaria Sphacelata, Urochloa Spp. Chloris gayana (giant rhodes), *Cenchrus ciliaris, Panicum coloratum* and *Panicum antidotale* showed promise in the preliminary adaptability test at 8 centres respresenting different agro-climatic regions of the country.

(*xi*) *Oil Seeds Scheme* (*I. C. O. C.*).

Out of a varieties of Sesamum, strain 'S' evolved at this Institute showed best performance (5·2 mds./acre) even under the most unfavourable weather conditions. Similarly 15 varieties of linseed from different States were tested. Varieties S36 and M 10 of linseed from Bombay and N_3 and N_{55} from M.P. suffered heavily on account of rust incidence. Variety K_2 from Punjab yielded the highest (14·02 mds./acre) closely followed by R. R. 45 (13·82 mds./acre) evolved at the I. A. R. I. In a mixed cropping studies on linseed with wheat and gram, pure crops yielded higher than mixed crops. Linseed yielded 12·5 mds./acre when mixed with gram as compared to 0·7 mds. when mixed with wheat. The total yield of the mixed crops. being 14·1 mds. and 11·1 mds./acre respectively for *linseed+gram* and *linseed+wheat* mixtures. In a fertilizer trial on linseed variety R. R. 9, the highest yield was obtained (24·27 mds./acre) with 30 lb. dose of nitrogen as against 19·17 mds. under the no nitrogen treatment.

3. Vegetable and Commercial Crops Section.

(*i*) *Response of sugarcane varieties to nitrogen doses.*

This is the third year of the experiment and results are summarised as under :—

Variety	Yield	Nitrogen/acre	Yield
	mds. acre		mds/acre
Co 647	849.7	No manure	668.4
Co 797	781.7	A/s 40 lb. N	711.7
Co 659	746.1	A/s 80 lb. N	742.0
Bo 11	690.8	A/s 120 lb. N	805.9
Co 739	680.0	S.E.m.	±10.2
Co 312	643.6	C.D. at 5%	29.1
S.E.m.	±25.5		
C.D. at 5%	80.3		

Among the varieties Co. 647 gave the highest yield closely followed by Co. 797 and was significantly superior to Co. 659, Bo.11, Co. 739 and Co. 312. Nitrogen levels 40, 80 and 120 lb. per acre showed significant effects. 120 lb. N per acre was found to be the optimum doze. In previous years 80 lb. N was the optimum dose. The interaction varieties-x-nitrogen levels was not significant.

(*ii*) *Fertilizer experiment on Cauliflower.*

This is the second year of the trial. Three levels of nitrogen 0, 60 and 120 lb ; three of P_2O_5 0, 40 and 80 lb. and three of M_0O_5: 0, 1 and 2 lb. per acre were the treatments applied to 'Snowball' Cauliflower. Responses to nitrogen and phosphate levels were significant the yields being 101·9 and 105 mds. per acre respectively under 60 lb. N and 40 lb. P_2O_5 as compared to 74·3 mds. under the control. The effects of further increases in N and P doses were not significant. M_0O_5 doses showed no effect on yields of Cauliflower.

(iii) Response of Peas varieties to levels of nitrogen & phosphate.

This is the first year of the trial. Three varieties of peas (N.P. 29, Early Badger and Bonneville) were grown under varying doses of nitrogen (0, 10 and 20 lb. per acre) and phosphate (0, 30 and 60 lb. P/acre). The results are summarised as follows :—

Yield of peas grain in mds/acre.

Variety	Yield	Nitrogen/acre	Yield	P_2O_5/acre	Yield
1. N. P. 29	30.67	no nitrogen	32.58	no. P_2O_5	26.69
2. Early Badger	20.23	10 lb.	33.26	30 lb.	31.04
3. Bonneville	42.60	20 lb.	27.67	60 lb.	35.76
S.E.m.	±1.88	..	±1.08	..	±1.08
C. D. at 5%	3.16	..	3.16	..	3.16

Bonneville gave significantly higher yield than N.P. 29 and Early Badger. Application of nitrogen at 20 lb. N reduced the yield significantly. Increasing doses of P_2O_5 brought about a significant and corresponding increases in yield. The responses to 30 and 60 lb. P_2O_5 are 4·35 and 9·07 mds. per acre respectively. The interactions were not significant.

(iv) Depth of cultivation, rates of fertilizations & method of placement experiment on potato and carrot.

Unlike last year, shallow cultivation with Desi plough and deep cultivation with tractor did not differentially influence the yields of Potato significantly. The yields varied from 272·99 to 285·10 mds./acre. Similarly, the methods of application, of fertilizers *i.e.*, placement (276·63 mds./acre) and broadcast (281·16 mds./acre) were equally effective. The optimum dose of fertilizer was found to be 120—80—80 (NPK)(293·82 mds/acre) as against last years optimum of 80—80—40 (NPK).

The cultivation treatments, fertilizer mixture and methods of placement, showed no effect on production of carrots.

(v) Vegetable growers holdings.

The project was started in 1955-56 to evaluate the economic production of 3-acre holdings on the basis of vegetable culture. The different systems of manuring were (i) F. Y. M. (ii) activated sludge (iii) ½ F. Y. M. and ½ fertilizers and (iv) Fertilizers. Half area in each holding was under 200% intensity of cropping and the other half under 300% intensity.

The highest profit of Rs. 249·77/acre was obtained from holding manured with F. Y. M. followed by holding manured with activated sludge yielding Rs. 196·22 per acre. Holding manured with fertilizer also showed a loss of Rs. 51·06 per acre.

4. Irrigation Investigation Shceme.

(i) Relationship between cropping pattern and irrigation intensities.

This project was started in *Rabi* 1955-56 with 12 three-year rotations of cropping intensity varying from 100 to 200% and irrigation intensity varying from 45 to 200%. Crops grown during the year under report were wheat, potato, berseem, sugarcane, cotton and maize. Wheat yielded (20·12 and 21·31 mds /acre) significantly higher with six inches and 7″ delta than 5″ delta (19·83 mds./acre) of irrigation in addition to consumed rainfall in the soil. Wheat after potato gave the highest yield (26·62 mds./acre) closely followed by wheat after berseem (23·72 mds. per acre) provided the field was kept fallow in *Kharif* season. Wheat after Jowar and cowpea gave the lowest yield (17·27 mds./acre). Three deltas (17·5″, 21·0″ and 24·5″) of irrigation

in seven irrigations of 2·5", 3" and 3·5" depth, were applied to potato in adition to 3·28" rainfall. Best results were obtained with 17·5" delta of irrigation applied in 2·5" depth of irrigation (326·80 mds./acre). The increase in yield over 24·5" delta of irrigation (266·98 mds./acre) was significant.

Berseem received 25, 30 and 35 acre inches of water in addition to 4"·12 rainfall. Yield under 30" and 35" irrigation (558·06 and 580·48 mds. per acre) were significantly higher than 25" irrigation (519·89 mds. per acre).

Similar results were observed under sugarcane where a delta of 35" in addition to 31·31" rainfall gave significantly higher yield (390·73 mds./acre) than other deltas. Cotton and maize did not show any significant differential response due to different irrigation levels varying from 10 to 14 acre-inches for cotton and 5 to 7 acre inches for maize in addition to 166 and 14·58 inches of rainfall received during the respective crop seasons.

(*ii*) *Response of wheat to levels of irrigation, nitrogen doses and seed rates.*

Three levels of nitrogen (20, 40 and 60 lb. N/acre) and seed rates (48, 64 and 80 lbs per acre) did not show significant differences among the various treatments. Four irrigations of 3" depth each yielded (19·41 mds./acre) significantly higher than three irrigations (16·82").

(*iii*) *Response of potatoes to delta & depth of irrigation; and levels of nitrogen.*

The effect of three levels of irrigations (17·5", 23·5" and 29·5" including rainfall), three depths of irrigation (2", 3" and 4") and three levels of nitrogen (80, 120 and 160 lbs./acre) was studied on potato yield. Levels of irrigation and nitrogen doses did not show significant effects. Two-inch. depth of irrigation increased the yield (203 mds./acre) significantly over four-inch depth (183 mds./acre) The Evapo-transpiration ratio increased with increasing levels of irrigation and depths of irrigation and decreased with increased nitrogen levels as summarised below :—

Evapo-transpiration ratio of potato

Irrigation	Ev.-T.	Depth of irrigation	Ev-T	Nitrogen doze/acre (Lb)	Ev-T
17·5"	252	2"	319	80	363
23·5"	338	3"	341	120	326
29·5"	427	4"	357	160	327
S.E.m.	±5.25	..	±5.25	..	±5.25
C.D. at 1%	22.00	..	22.00	..	22.00

The interactions were also significant. The reduction in Evapo-transpiration ratio by the application of nitrogen was most marked at highest level of irrigation, less at medium level and practically absent at the lowest level of irrigation. The increase in Evapo-transpiration ratio with increase at the highest level of irrigation and was less at medium and lowest levels.

(*iv*) *Relative efficiency of spray, flood and furrow irrigations on tobacco.*

Yield of tobacco increased with the quantity of water applied under each of the systems of irrigation. Under spray irrigation, the yield increasd from 868 lb. per acre with 4·25 acre-inches of water to 13·43 lb. per acre when the irrigation was increased to 6·75 inches in addition to 2·26 inch rainfall. An increase in furrow irrigation from 4·5" to 8·5" effected an increase of 346 lb. of tobacco per acre when the level of irrigation was raised from 6·5 to 12·5 acre-inches. Effect of nitrogen levels at 0, 20, 40, 60 and 80 lb. per acre was not evident. Spray irrigation at 0·75 acre-inch resulted in the penetation of water only within first foot of the soil.

(v) Response of sugarcane to levels of irrigation, nitrogen doses and seed rates.

The effect of three levels of irrigation (34", 47" and 60" per acre) three levels of nitrogen (60, 80 and 120 lb. per acre) and three seed rates (40, 60 and 75 mds. per acre) in all combinations was studied on yield, Evapo-transpiration ratio and commercial cane-sugar. The results are tabulated as under :—

Treatment/acre	Yield in mds/acre	Evapo-transpiration ratio	Commercial-cane-sugar mds/acre./
1. Irrigation—			
34"	696.87	1015.6	80.03
47"	806.47	1133.8	92.17
60"	751.82	1480.6	86.45
S.E.m.	±15.62	±30.16	±2.09
C.D. at 5%	45.98	88.43	6.13
2. Nitrogen.—			
60 lb.	702.62	1294.0	81.13
80 lb.	752.73	1195.6	86.61
120 lb.	799.72	1140.5	90.91
S.E.m.	±15.62	±30.16	±2.09
C.D. at 5%	45.98	88.43	6.13
3. Seed rates—			
45 mds.	710.28	1294.8	81.30
60 mds.	764.32	1190.5	87.92
75 mds.	780.58	1144.7	89.44
S.E.m.	±15.62	±30.16	±2.09
C.D. at 5%	45.98	88.43	6.13

Irrigation, nitrogen and seed rates showed significant effects. Optimum and significantly high yields were obtained with 47 acre-inches of water ; 80 lbs. nitrogen and 60 mds. of seed rate per acre. Evapo-transpiration ratio increased with the increase in the level of irrigation. High nitrogen doses on the other hand lowered this ratio and so did the higher seed rates.

(vi) Response of cotton to levels of irrigation, nitrogen doses and sowing dates. (14,22 and 30 *acre-inches*).

Irrigation levels did not show differential response. Effect of 40 lbs. N (15.90 mds./acre) was significant over 20 lbs. N (14·23 mds. per acre). Earlier sowings gave significantly highe yields than the later ones—crop sown on 1st May yielded 20·96 mds/acre as compared to 14·9 and 10·25 mds/acre from sowings done on 20th May and 1st June respectively.

5. Weed Control Investigation Scheme.

(i) Control of Sorghum helepense by Chemical and Cultural methods.

The treatments consisted of 2, 4-D (0, 5 and 10 lb. per acre) ; 2, 4, 5-T (0, 5 and 10 lb./acre) ; T.C.A. (0, 30 and 60 lb./acre) and number of cultivations (1, 3 and 6 per acre). Six cultivations reduced weed infestation by 70% as compared to the best chemical treatment)

(T.C.A. at 60 lb.[1] acre) affecting a 33% reduction. 2,4,5-T at 5 lb. T.C.A.at 60 lb. per acre yielded significantly higher than the control. Highest yield was obtained (13·6 mds./acre) with 6 cultivations.

(ii) Weed control experiment on wheat.

2, 4-D at 8 oz. and 1 lb. per acre effectively controlled almost all the broad leaved winter weeds such as *Anagallis arvensis*, *Euphorbia* sp., *Vicia Sativa*, *Heliotropium* Sp., *Chenopodium album*, etc. Application of 2, 4-D at 8 oz. per acre and liquid spray of ammonium sulphate at 30 lbs N gave significantly higher yield (18·7 and 18·8 mds./acre) than the control. Contrary to expectations the inter-cultivation treatments, however, showed little effect on yield.

(iii) Control of weeds in peas crop by weedicides and inter-cultivation.

M C P A at 8 oz. and 1 lb. dose per acre increased the yield of peas (22·5 and 24·0 mds./acre) significantly over the control (18·6 mds. per acre). Similar effect was observed under cultivation treatments where the yields were 23·4 and 22·1 mds./acre with one and two inter cultivations respectively as against 19·6 mds. per acre under the control.

(iv) Control of weeds in sugarcane.

The trial conducted to study the efficacy of 2, 4-D at 2 lbs/acre as pre and post-emergence spray alone and in combination with hoeings. Post-emergence application of 2, 4-D was more effective than pre-emergence application in controlling broad-leaved weeds. Pre-emergence application reduced the population of *Echinocloa colonum*, an annual grass, by about 50% whereas post-emergence application had practically no effect on this weed. Yield of sugarcane with pre-emergence application of 2, 4-D (953·9 mds./acre), 3 hoeings with bullock hoe (1048·9 mds./acre), pre-emergence application of 2, 4-D in combination with 3 hoeings (1113·9 mds. acre) and a combination of pre and post-emergence application of 2, 4-D and 3 hoeings (1180·5 mds. per acre) were highly significant over the unweeded control (718·3 mds./acre). These treatments gave extra yields of 235·6, 330·7, 395·6 and 462·2 mds. of stripped cane over the control in the order stated.

(v) Effect of various weedicides on weed in cotton.

Effect of 3 levels (3, 6 and 9 lb. per acre) of T.C.A. and P.C.P. as pre and post-emergence sprays; 4 levels of 2, 4-D (4, 6, 8 and 10 oz. per acre) as pre-emergence spray ; hand weeding and hoeing with bullock and also combination of T.C.A. and P.C.P. with hoeing was studied on weed control and cotton yield. Post-emergence application of P.C.P. caused burning of most of the broad-leaved weeds. T.C.A. at 9 lb. per acre markedly reduced the stand of *Echinocloa colonum* and other annual grasses. Best yield result was obtained with hand-weeding (15·0 mds./acre). The weedicide T.C.A. at 9 lb. per acre (13·6 mds./acre) also effected a significant increase in yield over the control (8·3 mds./acre).

(vi) Control of weeds in potato by chemical and cultural practices.

2, 4-D and M.C.P.A. both at 6 oz. per acre (271·1 and 284·3 mds. per acre) increased the yield of potato over the control (260·3 mds. per acre) but the difference was significant for M.C.P.A. only. Higher doses in both the cases (12 oz. per acre) caused a depression in yield. Treatments where potatoes were immediately ridged after planting produced significantly higher than where ridges were made at the time of earthing up. The increase in yield for these treatments were 47·9 mds. (Potato sown on flat and immediately ridged up) and 69·7 mds. (potato sown on flat, immediately ridged up, flattered later and again ridged up) over the common method of sowing.

6. Agricultural Extension Scheme.

Eight students in Agricultural Extension Course collected data pertaining to their respective investigations. They organized a 'Kisan' Mela at the Project Centre, Nangloi in May, 1957 which was a great success.

In the Intensive Cultivation Scheme the programme of varietal and fertilizer demonstrations was continued. Wheat variety N.P. 718 saturated on area of 2,775 acres against 2,099 acres in 1955-56. 7250 mds. of N.P. 718 seed from cultivators in the scheme area was supplied to the Bihar Government which had over 98% purity.

In crop cutting experiments in the Intensive Cultivation Scheme area N.P. 718 gave 3·4 mds. or 28·1% more yield than the local, which in the main is Pb.C. 591 wheat.

7. Coordinated Scheme of Fertilizer Trials on Cultivator's Fields.

The I.C.A.R. Scheme of Model Agronomic Experiments has been started from kharif 1955 on 16 centres and has now been extended to another 18 of which formerly were Complex Experimental Centres under the 'Fertilizer use Project'. During the *kharif* and *rabi* seasons of 1956-57, the 29 centres conducted 135 experiments on paddy, wheat, *jowar*, cotton and maize. The statistical analysis of the data are on hand and will be reported next year.

The Complex experiments conducted under the Fertilizer use Project were 69 on paddy at 11 centres. The responses to 20 & 40 lb levels of nitrogen were 2·6 and 3·6 mds./acre respectively. The average differences in response to sources of nitrogen ammonium sulphate, ammonium nitrate, ammonium sulphate nitrate, urea, ammonium chloride and Nitro chalk, were small. The average responses to 20 and 40 lb. P_2O_5 levels were 1·68 and 2·78 mds. respectively. Residual response of P_2O_5 was observed where the direct response had been indicated.

The cultivator field trials conducted in 10 Community Project area were 799. The average responses to 20 and 40 lbs. N/acre were 4.83 and 7·83 mds. respectively—a much higher response than in Complex experiments. The response to ammonium sulphate and urea was more or less equal at 20 lb. N. The responses to 20 and 40 lb. P_2O_5 levels were 2·9 and 3·9 mds./acre respectively. The average response to 20 lb. N + 20 lb. P_2O_5 was 6·59 mds./acre. Responses to potash in the presence of N and P_2O_5 was observed at selected centres.

8. Agronomic Experiments at Pusa.

(*i*) *Permanent manurial and rotation experiments.*

Maize yields due to organic manures were substantially higher than NPK treatments. Similar results were obtained with *arhar* and wheat. With these crops, NP and green manure in conjunction with superphosphate also gave high yields. There was heavy incidence of rust on the wheat crop.

(*ii*) *New manurial experiment.*

F.Y.M., NPK, NP, rape cake, N and NK treatments gave significantly higher yields of maize (12·17 to 18·54 mds./acre) than the control (7·82 mds. acre). Almost similar results were obtained with oats.

(*iii*) *Farm Economics.*

(*i*) *Farm Costing and farm efficiency studies.*– Employment position of work cattle and work output of major agricultural operations for the years 1953-54 and 1954-55 are given below :—

Percentage employment of work cattle

Particulars	1953-54			1954-55		
	Working	Rest	Sick	Working	Rest	Sick
1. Farm bullocks (Excluding C. C. A. and young bullcoks).	74.78	12.07	13.75	66.86	17.80	15.34
2. Farm bullocks including C. C. A. and young bullocks.	64.06	23.64	12.30	56.96	27.25	15.79
3. C. C. A. bullocks . . .	45.75	41.21	13.04	27.46	53.11	19.13

In the year 1954-55 there occurred a decrease in the employment of bullocks and an increase in the rest and sick percentages as compared to 1953-54 in spite of the fact that the number of bullocks was less in 1954-55 than in 1953-54. The study indicates that there is further scope in reducing the strength of bullocks.

Work output per pair of bullocks per day (acre)

Year	Ploughing with		Hoeing.
	Victory plough	Desi plough	
1953-54	0.26	0.44	0.82
1954-55	0.37	0.47	1.13

Output in 1954-55 of major agricultural operations per pair of bullocks per day was substantially (about 50%) improved particularly in respect of ploughing with victory plough and hoeing as compared to 1953-54.

(b) Seasonal fluctuations of manural labour employment were studied for the year 1955-56. The peak labour requirement was reached in April (5,751·75 labour units) followed by May and March (5,599·00 and 5,171·00 labour units).

The lowest number was employed in August (3,238·00 labour units). The peak season runs from October to December and again from March to June.

(iv) Cattle breeding and management.

(i) *General* :—The strength of the Sahiwal herd on 30th June, 1957 was 79 heads as against 78 at the close of the last year. The herd consisted of 36 cows, 3 stud bulls, 14 young male stock, 18 young female stock, 5 male calves and 3 female calves. Foot and mouth disease broke out in the herd on 8th March, 1957 which accounted for a number of deaths among the young stock and general deterioration in health of animals.

(ii) *Milk yield*— The wet and overall averages during 1956-57 were 21·4 and 15·0 lb. respectively, as against 23·5 and 15·5 lb. recorded last year. 24 cows completed their lactations during the year. Three of these yielded over 9,250, three over 8,290 lb., four over 7,000 lb. per lactation period of 306 days. The average herd yield was 6605.5 lb. per lactation.

(iii) *Calf rearing* :—Thirteen male and sixteen female calves were born during the year. The new system of rearing pailed calves introduced last year was continued. The calves are fed on standardized milk containing 3·5% butter fat, up to the age of one month and thereafter put on to skim milk upto the age of six months in the case of male and eight months in the case of female calves. These calves showed normal growth rate under the new system of feeding. The average growth rates of male and female calves were 1·06 and 1·07 lb. per head per day.

(iv) *Early maturity experiments*:—Early matured heifers on an average yielded 5,022 lb. of milk in the first lactation as against 6,680 lb. for the second calvers and 7,339 lb. for the adults. Average age at first calving of the heifers was 2 years, 6 months and 5 days.

(v) *Sale of Cattle*:—Five young bulls were sold to four parties at a total price of Rs. 3,200.

(vi) *Key Village Scheme*:— The fourth Key Village Centre and one Artificial Insemination centre were set up at Nangloi : Castration operations against scrub bulls were continued in 19 villages. Over 400 buffaloes and 250 cows were served by the improved bulls stationed at these centres. Necessary advice in feeding of cattle and treatment of diseases was given to the stock breeders in the area.

Programme of Work for 1957-58

1. *Soil fertility Section.*

   (i) Building up of soil fertility through organic manures and inorganic fertilizers.

   (ii) Building up of soil fertility through phosphate manuring of legumes.

   (iii) Building up of soil fertility through crop rotations.

   (iv) Experiments on 6-acres cultivator holdings.

2. *Field crops section.*

   (i) Response to manures and fertilizers.

   (ii) Cultural experiments.

   (iii) Varietal trials.

   (iv) Agronomic experiments on grasses and legumes for forage and pasturage.

   (v) Grassland Scheme (I.C.A.R.).

   (vi) Oil seed Scheme (I.C.O.C.).

3. *Vegetable and Commercial crops section.*

   (i) Response to manures and fertilizers.

   (ii) Cultural experiments.

   (iii) Varietal trials.

   (iv) Vegetable growers' 3-acre holdings.

4. *Farm and cattle section.*

   (i) Line breeding and Selection for improvement in milk yield.

   (ii) Feeding of stock on balanced ration for optimum growth, early maturity and high milk yield.

   (iii) Rearing of pailfed calves on skim milk.

   (iv) Intensive cultivation scheme.

   (v) Key Village Scheme.

5. *Projects under Second Five Year Plan.*

   (i) Irrigation Investigations Scheme.

   (ii) Weed Control Investigations Scheme.

   (iii) Agricultural Extension Scheme.

   (iv) Plant Tissue Tests and Spray Fertilization Scheme.

6. *Agronomic Experiments at B.S.S. Pusa.*

   (i) Permanent manurial and rotation experiments.

   (ii) New manurial experiments.

Agricultural Research Sub-Station, Karnal

Response of Crops to Seasons.

The total rainfall from 1st June, 1956 to 31st May, 1957 amounted to 48·55 inches as against 37·10 and 28·34 inches recorded during the corresponding periods of 1955-56 and 1954-55 respectively. The rainfall was much above the normal which is 25·89 inches. *Kharif* crops suffered due to excessive rains in August (19·51"). Continuous rains in October submerged the paddy crop and caused immense loss.

The yield of the principal crops grown on the farm during the year, together are given below :—

Crop	1956-57		Remarks
	Area	Yield/acre	
	acres	mds.	
Grain—			
Paddy	35.94	32.01	
Cotton	13.15	10.83	Heavy rain in Oct. caused damage to bolls.
Wheat	138.47	20.25	
Oats	5.00	21.97	
Gram	11.13	20.16	
Peas	4.50	23.37	
Fodder—			
Jowar	15.60	176.82	
Cowpea	3.00	192.00	
Maize and cowpea	2.67	337.45	
Berseem	1.63	244.46	Sown very late due to flood and heavy rains in October.

Research Projects.

A. Manurial experiments.

Fertilizer value of ammonium chloride and ammonium sulphate-nitrate :—There were no significant differences among ammonium sulphate, ammonium sulphate-nitrate and ammonium chloride and 40 lbs. and 20 lbs. doses of nitrogen on paddy. Fertilizer treatments were significantly superior to control. Similar results were obtained with wheat crop.

Experiments Conducted under T.C.M. Project.

Levels and types of nitrogen and levels of phosphate on non-acid soils :—Differences amongst the sources of nitrogen—ammonium sulphate, ammonium nitrate and urea–were not significant. The highest yield of 38·5 maunds was obtained with 60 lb. N and 40 lb. P_2O_5.

Varieties and fertilizers :—The variation in yield of paddy varieties N.P. 97 and N.P. 130 (medium fine varieties) and local coarses Jhona variety was small. Interactions between varieties and nitrogen levels or phosphate levels were not significant.

In the case of wheat 40 lbs. N (21·24 mds./acre) was significantly superior to 20 lbs. N (20·12 mds./acre) which in turn was significantly superior to 0 lb. N (18·29 mds./acre). 20 lbs· P_2O_5 (19·40 mds./acre) was significantly superior to 0 lb. P_2O_5 (18·24 mds./acre) and was

at par with 40 lbs. P_2O_5 (19·00 mds./acre). Among the varieties N.P. 718 (28·72 mds./acre) was significantly superior to N.P. 710 (21·20 mds./acre) which again was significantly superior to local variety (12·79 mds./acre).

Effect of artificial fertilizers in conjunction with organic manure :—The treatments of 40 lbs. of fertilizer N/acre and 20 carts of F.Y.M./acre produced 52·56 and 51·37 mds. of paddy per acre respectively. The yield of the control plot was 41·8 mds./acre.

The nitrogen treatments of 20 and 40 lbs. N were found to be significantly superior to 0 lb. N/acre (23·75 mds./acre). The difference due to F.Y.M. treatments of 0, 10 and 20 cartloads were not significant.

Time of application of fertilizers— The differences in yield of paddy due to various times of application of ammonium sulphate and urea were not found significant. Similarly the application of ammonium sulphate, ammonium nitrate and urea did not show significant difference in wheat yield applied either at sowing or at first irrigation.

Placement of fertilizers:—The four methods of application of phsophate consisted of (i) broad casting at pudding (ii) drilling at pudding (iii) dipping the seedlings in mud slush mixed with fertilizers at transplanting and (iv) pellets, a fortnight after transplanting. Application in pellets gave the highest yield of 36·29 mds./acre. Differences amongst the treatments were, however, not significant.

B. Varietal trials.

Varietal trial of the fine and mid-fine types of paddy :—The 12 varieties of paddy tested were N.P. 125, N.P. 130, N.P. 137, Palman 34-22, Begmi 290, Palman 246, T 21, Sonpatter 4-12-19, Begmi 292-19, T. 9, Basmatti 370, and Sonpatter 7-2-5, for their yields. The high yield was given by N.P. 130 (31·3 mds./acre) and low by Sonpatter 7-2-5 (20·83 mds./acre).

Varietal trial of coarse and mid-coarse types of paddy :—The varieties of paddy under trial were 21. The differences amongst the varieties were not significant. *Jhona Kesarwala* S-20 (29·43 mds./acre) produced the highest yield and the lowest yield was obtained from CH. 10 (23·83 mds./acre).

Wheat varietal trial :—Wheat varieties N.P. 718, N.P. 792, N.P. 797, N.P. 798, N.P. 799, C. 281, and C. 591, were tested for their yield performances both under 'irrigated' and 'barani' conditions. In contrast to the previous years the performance of N.P. 718 was rather poor. It is suspected a new race of yellow rust infected the crop and reduced its yield under irrigated conditions.

C. Cultural experiments.

Tillage of wheat in conjunction with green manure and fertilizers :—The three types of tillage used for preparing seed bed were:

1. Tractor and allied implements *viz.* grubber and disc. harrow.
2. Victory Bullock drawn inversion plough-cum-country plough.
3. Country plough only.

The differences in yield due to cultivation treatments were not significant. Among the manurial treatments green manure, F.Y.M. @ 60 lbs. N, Ammonium sulphate at 30 and 60 lbs .N, phosphate @ 30 lbs. P and all their combinations proved to be significantly superior to' No manure'. The highest yield of 24·70 mds./acre was produced by the green manure and 30 lbs. N as ammonium sulphate and 30 lb. P_2O_5/acre. Green manure and 30 lb. P was significantly superior to green manure alone but F.Y.M. and 30 lb. P was not significantly superior to F.Y.M. alone.

D. Cultivators' holdings.

Long term experiments with revised cropping schemes with 6-acre cultivators' holdings started last year were continued this year also. The levels of yields were sufficiently high to meet the requirements of the average sized family and cattle maintained for cultivation and milk production.

Seed supply :—About 1389 mds. of seeds of improved varieties of crop were distributed to growers during the year.

Report of the Section of Statistics

Research Projects.

1. *Analysis of Lattice Experiments.*

Theoretical investigations on method of analysing lattices and lattice squares designs were continued. The work is nearing completion.

2. *Genetical aspect of milk improvement in Sahiwal Herd.*

Studies on the persistency of milk yield and the nature of the lactation curves for the cows in the Institute herd were continued. 15 cows were selected from each of first two lactations and correlation coefficients were worked out between the arithmetic and geometric means for the first 4, 6 and 8 weeks of milk yield and the lactation yields. The correlations were found to be highly significant, although the association was slightly weaker for cows in the second lactation. The work is being continued with a larger group of 60 cows in each of the first two lactations.

Growth rate of the early matured cow 'Tamili' was studied and was found to be represented by the equation :

$$W = e^{4.062 + 0.067t - 0.000424\ t^2}$$

The average growth rate till the date of calving was 6·97 lb. per week and was maximum *i.e.* 13·93 lb. per week during the 23 weeks' period just preceding the date of service.

3. *Permanent Manurial Experiments (Old Series) : I—Study of Maize yields* (1930-54).

The statistical analysis of 24 years' yield data of maize crop was completed after transforming the data into logarithms. The analysis under series A and B indicated significant differences between (i) Organic Manures, (ii) Chemical fertilizers, and (iii) Rotations including green manures. The results show that the organic manure, namely, F.Y.M. @ 4,000 lbs. plus Rape Cake @ 20 lbs. N per acre raised the yields in both the series. Among the inorganic treatments, the complete fertilizer NPK gave the highest yield.

4. *Analysis of Water Table Records* (1940-54).

Records of the thirteen wells situated in the Institute fields for the 15 year period were analysed. The statistical analysis indicated significant differences among the water levels of the wells taken over the years in each month. Differences between yearly levels were also found to be significant.

The wells situated in the Main block and in the Division of Botany were generally at a low level. There was little change in the water levels from January to April, from May to August and from September to December. In general the levels were low during the summer and high during September to December.

5. *Sampling Methods for Growth characters and yield of crops.*

(a) *Sampling for height of plants in Jowar*:—Observations were recorded from a 1/25th acre plot and the analysis of height measurements in the 3′ and 4′ units units indicated that there was little difference between the two sampling units. The number of samples necessary to estimate the average height with 4% error were found to be as follows :—

No. of rows	3	4	5
No. of 3′ units in each row	6	4	3
% Sampling	5.2	4.6	4.3

To obtain results with 3 per cent error the number of the samples in each row must be doubled.

(*b*) *Plant Population*:—3′ sampling unit was found to be unsuitable on account of high sampling errors. With 6′ and 9′ units the percentage error was still as high 7 per cent with a 5 and 6½ per cent sample.

(c) *Sampling for wheat yields*:—Random samples of 10 and 20 per cent of the tolal produce were taken twice from each of 36 plots from an experiment in 1956-57. Statistical analysis did not indicate any improvement in estimation with 20% sampling. Further, the standard errors with both methods of estimation and one to four samples per plot were as high as 10–15 per cent, thus rendering the sampling procedure unsuitable for estimating treatment mean yields. The high per cent errors may be attributable to low grain setting on account of the hail storm. (Average grain to total produce ratio in the experiment was only 0·21).

(d) *Sampling for yield with Maize* :—Random samples of 10 and 20 per cent of the cobs were taken twice from each of 72 plots from a weedicide experiment in *kharif*, 1956. The grain weight and the ratio of grain weight to total weight were recorded for each sampling unit. The statistical analysis indicated no reduction in percentage errors with 20% sampling. Using the grain weights, the estimated % errors in the treatment means with one to four samples ranged from 7 to 11%. However, using ratios of grain weight to total weight, the errors ranged only from 2·2 and 3·8%. It was thus found that taking two samples of 10 per cent and using the ratio of grain to total weight the treatment mean yields could be estimated with only 2·8 per cent error.

6. *Crop Cutting experiments in the villages under the I.A.R.I. Intensive Cultivation Scheme.*

Crop cutting experiments were carried out in the three villages of Mundhka, Nilwal and Nangoli Jattan with a view to study the performance of NP 718 variety of wheat over the local as grown by the cultivators as well as in the demonstration plots. The increase in yield due to NP 718 over the local in the cultivators' fields was 3·4 mds. acre or 28·1%, whereas in the demonstration plots the increase was only 1·6 md./acre or 10·8%. However, the differences were not statistically significant. The yields this year were poor as compared to the previous year's results.

STATISTICAL ANALYSIS OF DATA FROM DIFFERENT DIVISIONS.

Analysis of the data of six factorial experiments from the Agronomy Division, data of drought series from Botany Division; data of two experiments from Entomology Division and data of three series of experiments from Chemistry Division were carried out in the Statistical Section. The details of analysis have been reported to the respective Divisions of the Institute.

REPORT OF THE DIVISION OF BOTANY

(Including the Botanical Substation, Pusa, and Vegetable Breeding Substation, Katrain)
(Dr. S. M. Sikka)

The research work in the Botany Division continued under the five sections, namely, Plant Breeding & Genetics, Cytology & Cytogenetics, Crop Physiology, Plant Introduction and Agrostology. The main objective of this work was the breeding of improved varieties of different crop plants, vegetables, pasture grasses and legumes. In recent years there has been a growing realisation that while the agricultural crop plants must continue to receive the major attention of plant breeders in the country, the development of floriculture should not be neglected. Moreover, in this field of work remarkable results can be achieved, and have been achieved in western countries, by the application of the latest cytogenetical techniques such as colchicine induced polyploidy and radiation induced mutations. With these considerations in view, work on the breeding of ornamental plants has been initiated for the first time in India. The Section of Horticulture has become a full-fledged Division of Horticulture.

For setting up a laboratory for testing the milling and baking qualities of Indian wheats, the T.C.M. is providing the technical assistance of an expert as well as the necessary equipment. In this connection Dr. C. C. Fifield, Baking Technologist, U.S.D.A. visited the Institute for a short period and had discussions with the concerned staff members. He has also drawn up a plan for the building and prepared a list of the equipment required. The Rockefeller Foundation is helping us in the improvement of cereal crops. For organising the work on maize breeding, the Foundation has deputed an expert, Dr. U. J. Grant. It has also agreed to supply valuable field and laboratory equipment such as tractors, vehicles, seed drying and processing unit, etc. Some of this equipment has already arrived.

There is an abundance of algal types in India and some algae like *Chlorella* are potential sources of food while others such as *Tolypothrix tenuis* are powerful nitrogen fixers. But practically no information is available on their genetic variability. Under an I.C.A.R. Scheme, the study of Indian algae has therefore been taken up with the object of finding out which of them would be useful as sources of food or as nitrogen fixers. Work under other research schemes of the I.C.A.R. and Commodity Committees as well as the Second Five Year Plan schemes made satisfactory progress.

On the 20th March, 1957, there was a severe hailstorm accompanied by strong winds This has caused serious havoc to the crops in the Division, particularly wheat, barley, linseed, brassica, various essential oil-bearing plants, tomato and other vegetables. All care was taken to save as much of the breeding material as possible by staking up the plants. The hailstorm has seriously upset the yield trials in the various crops since the data collected on the badly damaged plots cannot be reliable.

Collaboration with other research institutions in India and abroad continued in regard to the exchange of information, seeds and planting material. The Division has also participated in a project of the Food and Agriculture Organisation of the U.N.O. for testing on a co-operative basis a number of wheat and barley varieties for their reaction to major diseases like rust and bunt in various countries of the Near East.

Advisory work and distribution of pure seeds of improved varieties of different crops, including vegetables, continued as in previous years.

The results in the main lines of work are summarised below:–

Plant Breeding and Genetics

1. Improvement of Indian Wheat.

The work on wheat improvement is being carried out at Delhi and its substations located at Simla, Pusa, Indore, Wellington and Bhowali. While the centres at Delhi and Pusa cater to the needs of the plains, the breeding centres at Simla and Bhowali concentrate on the

improvement of hill wheats. The main objective of the wheat work at this Division is the poduction of agronomically superior strains of wheat which combine in them resistance to the major diseases like rusts and smuts. This concerns not only wheats suitable for different regions like hills, plains etc., but also different cultivated species of wheat like *durum* and *dicoccum*. The work at Indore is directed towards the improvement of *durum* wheats and the work at Wellington towards the improvement of *dicoccum* wheats. Work is also in progress to evolve strains of wheat which respond to different levels of fertility. Assessment of the *chapati*-making qualities of Indian wheats is a new line of work that has been started during the year. This will be linked up with the milling and baking tests on Indian wheats when the laboratory for these tests is constructed. In addition to the applied aspects of wheat breeding work, systematic studies on the fundamental aspects of the genetics of rust and smut resistance and other important characters of wheat have been in progress.

(i) *Improvement of common bread wheats for the plains:* A large number of selections from crosses involving rust resistant parents like Rio Negro, Frontiera, La Prevision, Cometa Klein, Kenya 184 P. 2. A.I.F., N.P. 790, N.P. 785, E 871(a Timstein deriavative) etc. on the one side, and improved Indian wheats such as N.P. 710, N.P. 718, N.P. 761, N.P. 775, N.P. 758, C 281 etc. on other, were under study. A number of selections, in advanced generations, have been obtained which combine in them high resistance to one, two or all the three rusts, coupled with good agronomic characters. Progeny row trials were conducted with 684 promising selections obtained from 40 different crosses in F_4 to F_7 generations. Most of these selections are derived from crosses involving resistant parents such as Rio Negro, Kenya E 220, Ridley, N.P. 790, Gabo, Kenya 184 P2 A.I.F., Frontiera, N.P. 789, N.P. 801, etc. A number of these selections show promise with regard to yield and rust resistance. Some of these selections have been observed to give very encouraging results also at Tollygunje in West Bengal, Bhowali, Simla and Pusa (Bihar).

Interspecific hybridisation was also in progress and *durum* parents such as Gaza, E 2025 (Arabian *durum*), E 2158 (Egyptian *durum*) and *dicoccum* wheats like I.C. 1057 (*T. dicoccum*) are being used as sources of rust resistance. A large number of selections have been obtained from the crosses of Gaza with N.P. 710, N.P. 718, C 281 and C 591, which combine in them a high degree of resistance to rusts and good grain quality.

A number of progenies were tested for their seedling resistance to a mixture of races of each rust separately. Ten out of a total of 237 were resistant to black rust, 54 out of 194 to brown rust and 56 out of 162 to yellow rust. Three of these selections possess combined resistance to black and brown rusts, eight for brown and yellow and one for all the three rusts.

With a view to introduce lodging resistance into improved Indian wheats such as N.P.710, N.P. 718, N.P. 761, N.P.794 etc., crosses were made between them and two lodging resistant wheats *viz.*, E 2628 and E 2629 obtained from Cambridge. The second dose of back-crossing has been given in this material, with the Indian wheats as the recurrent parents.

The work on wheat breeding at the Pusa centre is concerned mainly with the development of improved varieties suitable for the eastern parts of the country. About 632 selections from F_2 to F_6 generations of 71 crosses and 462 selections from 62 back-crosses were made on the basis of rust resistance and other desirable characters. For studying the yielding capacity in progeny row trials, 126 selections have been made in the various crosses.

(ii) *Improvement of common bread wheats for the hills:* With a view to further intensification of desired characters in the existing improved hill wheats, a large number of crosses in the early as well as advanced generations were studied for their rust resistance and other characters at the Simla centre. Of these, the most promising rust resistant selections comprising 46 progenies in F_3, 85 in F_4, 43 in F_5, 37 in F_6, two in F_8 and ten in F_9 were also included in progeny row trials. The material harvested includes approximately 25,000 single plants for detailed laboratory examination. A number of selections from the promising crosses showed good yield characters and grain quality combined with a high degree of yellow rust resistance. Some of the selections were also seen to combine a high degree of resistance to black and brown rusts under artificial conditions of infection at Simla.

(iii) *Improvement of* durum *wheats:* This work is conducted at the Indore Centre which represents the *durum* tract. During the year, 902 progenies from 94 *durum* crosses, 289 progenies from 76 *vulgare* crosses and 66 progenies from 19 interspecific crosses were tested for resistance to black rust under artificial conditions of infection. The best selections, combining rust resistance with good agronomic characters were obtained from the crosses (E. 931 × E.K.6), (E.931 × Egypt 8626) × Niphad 5-67-14-26-3, (E. 931 × Kenphad 25), (N. P. 789 × N. P. 710), (E. 952 × N. P. 760), (N. P. 758 × E. 572) and (N. P. 799 × N. P. 771) × C 228 which were in F5 to F7 generations.

(iv) *Improvement of* dicoccum *wheats:* By pure line selection from the local cultivated *dicoccum*, a strain *viz.*, P.D. 13 was isolated at the Wellington Centre. The new selection, P.D. 13 has high field resistance to yellow and brown rusts. In yield trials, it is significantly superior to the local wheats. This strain is now ready for release for general cultivation in the hills of southern India.

Promising selections were obtained from the cross (K. K. 568 × Local) which combine resistance to brown and yellow rusts coupled with easy threshing quality. The latter character will be a great benefit to farmers in this region. Some of the selections of the cross (E 871 × Gabo) showed resistance to powdery mildew as well as to the prevalent rust races of that area.

(v) *Breeding for resistance to loose-smut:* Out of 61 wheat varieties inoculated with loose-smut at Delhi, 34 were found to be completely free from this disease. These include such rust resistant types as HD(52)-35, HD(52)-46, HD(52)-66, HD(53)-87, HD(53)117, HD(53)134, HD(53)-146 etc. which are now in the final stages of testing. In a search for loose smut resistant substrains of N. P. 775, about 480 smut-free plants had been inoculated during 1955-56 and their progenies grown during the year under report. Out of these, 68 progenies showed either complete freedom from the disease or only 2 or 3 smutted plants. From these 68 progenies, 148 single plants have been inoculated for further study.

(vi) *Breeding for resistance to bunt:* Seeds of 55 wheat varieties inoculated with hill bunt spores (*Tilletia foetida* and *T. caries*) were sown in a replicated trial at Simla for the purpose of determining their resistance to the disease. As in the previous years, very good infection was obtained. From the observations recorded by the staff of the Mycology Division, indications are that the exotic varieties, E 201(Hussar), E 56(Khapli), E 740(*T. dicoccum* from Arabia) and E 2327(Brevor) are resistant to the disease. These four varieties showed resistant reaction during 1955-56 also. They will be taken up for tests at the different altitudes during the coming season.

At Karnal, 95 wheat varieties were inoculated with Karnal bunt (*Neovossia indica*) at the boot stage by the Mycology Division. Fairly good infection was obtained. About 41 varieties escaped infection. These included a number of exotic wheats such as E 931 (Gaza), E 952(Rio Negro), E 957 (Frontiera), E 581 (Kenya) etc. Among the N. P. and recently evolved wheats, N. P. 789, N. P. 790, N. P. 784, N. P. 786, HD(52)-33 etc. were promising.

(vii) *Improvement of the chapati-making qualities of Indian wheats* : A standard method of making *chapatis* and testing the *chapati*-making qualities of different wheat varieties has been evolved. The assessment of *chapati* making qualities involves a score-card system in which a number of judges independently award marks for each of the three characters, *viz.*, (1) appearance, (2) taste and (3) texture. Taking the average of these three characters, the varieties that scored 7 to 8 marks out of a maximum of 10 marks were: N. P. 716, N. P. 718, N. P. 792, N. P. 798 and N. P. 799 among the recently bred rust resistant wheats. The old wheats, N. P. 4, N. P. 52 and C. 591 also came in this class.

(viii) *Yield trials of promising varieties and strains:* About 47 trials were conducted in the plains with the newly developed rust and loose smut resistant wheats *viz.*, N. P. 797, N.P. 798 and N. P. 799. From the results received so far, it is evident that these new varieties are maintaining their superior performance at different places. At Aliabada in Saurashtra, N. P. 799 and N. P. 797 were first and second with yields of 1255 lbs./acre and 1202 lbs./acre respectively. The yield of N. P. 798 was 1141 lbs./acre while the local gave only 206 lbs./acre at this place. These three strains gave equally outstanding performance under rain-fed conditions at Hyderabad where N.P.799, N.P.797 and N.P.798 were first, second and third with yields of 1239 lbs., 1203 lbs.

and 1176 lbs. respectively while the yield of the Local was only 356 lbs. per acre. These three strains occupied the first three places at Rewa (M. P.) with yields of 1590 lbs.(N.P.797), 1494 lbs. (N.P.798) and 1457 lbs. (N.P.799), the yield of the Local being 1091 lbs. per acre. At Powarkheda (M.P.) also, under *barani* conditions, these strains occupied the three top places with yields of 803 lbs. (N.P.799), 764 lbs. (N.P.798) and 737 lbs. (N.P.797) whereas the M.P. wheats, Hyb. 11 and Hyb. 65 gave yields of 686 lbs. and 560 lbs. respectively. In the irrigated trial at Dohad (Bombay State) again, these strains were the best three and in the *barani* trial at this place, N.P.799 was the top-yielder. At Bankura, N.P.798 was first (1126 lbs.) and N.P. 797 was second (988 lbs.) while the Local gave a yield of 773 lbs. per acre. In Bihar, these three strains recorded superior yields both under irrigated and unirrigated conditions.

Trials were also conducted with a number of recently developed strains. Out of them, HD(52)-27 distinguished itself at Karnal where it stood first in both manured and unmanured series, giving a response of 148% under manuring. At Delhi, HD(52)-67 and HD(52)-66 occupied the first and third places in an irrigated trial, with yields of 1951 lbs./acre and 1860 lbs./acre respectively in spite of damage due to hailstorm. HD(52)-67 was second in order of merit in the *barani* trial at this place and gave 1664 lbs./acre. In a trial at Jaipur (Rajasthan), HD(52)87 stood second in order of merit. Certain of the selections which are now in an advanced generation from the cross (Rio Negro × N.P.760) are also very promising from the standpoint of rust resistance, high yield and good grain quality.

As in previous years, a large number of trials were conducted with N.P. wheats in the hills of Himachal Pradesh, Punjab, Uttar Pradesh and Jammu and Kashmir. Separate set of varieties for the high as well as the low elevation hills were included in these trials. The results so far received again establish the superiority of Ridley for the lower hills and N.P.770 and N.P.809 for the medium to higher hills. N.P.813 showed a very high degree of rust resistance and out-yielded the other varieties in the lower hills at a few places.

HD(53)-146-a new promising wheat has again out-yielded all the other varieties including improved controls in some of the tests in the lower hills this year. This variety holds a promising future, in this region.

In most of the trials conducted with the *dicoccum* wheats in the Nilgiri hills, one isolate *viz.*, P.D.13 has continued to give the best performance.

(ix) *Genetics of rust resistance and other characters:* Extensive studies were conducted in the genetics of rust resistance (seedling as well as adult reaction) and other characters such as awning, grain colour, auricle hairiness, glume hairiness, glume colour, etc.

Seedling resistance to race 15 of black rust was studied in 10 crosses of *T. aestivum*, and there are indications that reaction in this instance is controlled by one, two or three dominant genes for susceptibility depending upon the resistant parent. Similarly reaction to races 24, 75, 194 and 117 in the cross C. 591 × N.P.790, is controlled by duplicate factors, with dominance of resistance. Resistance to race 15-C of black rust was studied in five crosses of N.P.790 parent (resistant) and it appears that resistance is controlled by a single recessive gene. Field reaction to yellow rust was studied in three crosses of N.P.785 with susceptible N.P.710, N.P.718 and C. 591 and it was observed to be simply inherited with dominance of resistance. Characters like auricle hairiness, glume hairiness and glume colour were found to be simply inherited. E 1913 (kenya-gular pilot × k-58 New-thatch) was found to carry one dominant gene for red grain colour while E 1844 (Supremo × Mentana) has two factors. Similarly tip awned Kenya E 220, Ridley and E 1951 (Kenya 338 AC.2.E.2, I-49-89) were found to differ from the fully awned variety N.P.718 by a single gene pair for this awn character. With a view to study the combining ability of the different rust resistant parents, crosses were attempted with these using N.P.718 as the common parent. The F1 and F2 generations of these crosses were grown during the year.

(x) *Assessment of exotic wheats:* About 1047 foreign wheat varieties were received including 284 from the F.A.O. for co-operative studies with other countries in the Near East. Only the Near East Rust Nursery material could be studied under artificial conditions of infection.

Twenty-four varieties showed resistance to yellow rust, 11 to brown rust and 24 to black rust. Apart from these, 46 varieties showed combined resistance to black and yellow, 10 to brown and yellow and 1 to black and brown. One variety *viz.*, E 2726 (an amphidiploid of *Aegilops triuncialis* × *Triticum timopheevi*) received from Cambridge was found to be free from all the three rusts. Out of a number of varieties tested in the seedling stage against mixtures of all the races of black, brown and yellow rusts, 18 were found to be resistant to brown, 9 to yellow and 6 to black rust respectively. A number of these foreign wheats were also tested against loose smut and some useful varieties were located.

(xi) *Breeding varieties for different levels of fertility:* Trials were conducted at Delhi, Karnal, Pusa and Indore with a number of the newly evolved hybrid strains and certain other N.P. wheats, with a view to find out their response to different fertility levels. The hybrid strain HD(52)-27 gave the highest yield both under manured as well as unmanured conditions at Karnal. At Pusa, HD(53)-105, HD(52)-46 and HD(52)-35 (alongwith N.P.799, N.P.798, and N.P.797) gave the best performance. Two strains *viz.*, HD(53)-134 and HD(52)-46 have given indications of superior performance under different agronomic conditions, as is evident from the data collected over a period of three years; they are doing very well under high as well as low fertility levels, late as well as normal sowings and irrigated as well as unirrigated conditions.

2. Breeding rust and smut resistant barleys

This work was in progress at Delhi and the Wheat Breeding Substations at Simla, Pusa and Wellington. In a search for disease resistant genetic stocks, forty six exotic barley varieties received from U.S.S.R. and F.A.O. were tested for rust resistance under artificial conditions of infection at Delhi. Proctor (a two-rowed barley) was observed to be free from the attack of yellow rust. The varieties that showed freedom from black rust attack were *H. vulgare* K. 10199 and *H. distichon*, 8485 from U.S.S.R. and B.22, F.48, Saifi (E.C.10619, E.C.10620, and E.C.10622) from Jordan. A suitable hybridization programme to breed varieties resistant to rusts and possessing other agronomic characters was under way. A number of crosses were studied for rust resistance and other characters in the F2 generation and information on the inheritance of some of the characters has been obtained. Susceptibility to yellow rust was dominant in the crosses studied and the F2 segregated in a simple monohydrid ratio. Virescence of seedlings behaved as a simple recessive to the normal green. Hooded condition of the lemma tended to be dominant, the ratio in the F2 being 3 hooded to 1 awned. A one-factor difference was detected between the 2-rowed type and the 6-rowed type of ear, the F1 being the 2-rowed type of ear. The 6-rowed *vs.* 2-rowed condition of the ear was found to be independent of the hooded *vs.* awned condition of the lemma.

At Simla, 48 varieties of barley were tested in four trials. Selection Nos. SL B2, SL B9, SL B13 and PS_8 outyielded the local and N.P.100 used as controls.

At Pusa, four hundred and eleven varieties were tested for their reaction to the rusts out of which 265 were resistant to or free from yellow rust, 52 to black rust and 25 to both. N.P.21 gave the best yield in a varietal trial of the varieties, N.P.13, N.P.21, BR.22, BR.30 and local.

At Wellington, resistance to loose-smut and the prevalent races of yellow rust has been successfully introduced into the naked-grained, 6-rowed local barley from varieties B.220 and B.150 by means of a back crossing programme. This material is under further selection.

3. Hybrid maize

During the year, 3000 inbred lines were isolated and 150 were imported from the U.S.A., Mexico and Columbia. About 320 top crosses were also produced for studying the general combining ability of inbred lines.

In a trial conducted with an exotic maize hybrid N.C.27, produced at the Indian Agricultural Research Institute from parental acclimatised inbred lines, the grain yield was 75 maunds and 12 seers per acre, as compared to 42 maunds and 7 seers by K.T.41, an improved Indian open pollinated variety.

In another trial with three locally produced exotic hybrids (N.C.27, Texas 26 and U.S.13), conducted at Delhi, Arbhavi (Mysore State), Kanpur (U.P.) and Udaipur (Rajasthan), the yield of the hybrids expressed as percentage of the best local, ranged from 175 (for Texas 26) at Delhi to 86 (for U.S.13) at Arbhavi. The hybrids matured at the same time as the local or were 5 to 6 days later in maturity.

Seventy two single crosses were also tested in trials for studying the specific combining ability of certain lines. Twenty-two single crosses significantly outyielded the check K.T.41. The yield of these significantly higher yielding crosses, as expressed in percentage of the check ranged from 195·9 for S.C.37 to 135 for S.C.30.

About 309 inbred lines in S1 and later generations were studied for their general combining ability. Sixty seven top crosses significantly out yielded the tester variety. The yields of these better performing top crosses, expressed in percentage of the tester, ranged from 206 for the top crossed line Dixie 18-1-3-3 to 134 for K.T.41-58.

With a view to incorporating male sterility into inbred lines of Indian flint corn, a Texas source of cytoplasmic male sterility was crossed to 7 Indian inbred lines. The seven crosses were found to be male sterile and were back crossed to the Indian parent.

4. Improvement of Millets

(i) *Jawar:* 265 cultures of jowar including 172 exotics were studied for their genetic variability with regard to mean flowering date, ear size, type of ear, grain weight, grain colour, height of plant etc. The mean flowering date varied from 47 days to 120 days after sowing. 36 cultures were early maturing (47 to 60 days), 60 were medium maturing (61 to 72 days) and the rest were late maturing (75 to 120 days). The hundred grain weight ranged from 1.0 gm. to 5.43 gms. The exotic variety, KORGI, from East Africa still remained the boldest seeded variety (5.43 gms.). Among the indigenous strains, I.C.3664, a jowar strain No. 8/52 from Sirsa (E. Punjab) has got the boldest grain (5.0 gms.). A secondary selection in Early Prodigy was found to be about 10 days earlier than the parent variety.

Forty-eight jowar strains were tested for their grain and fodder yields in a preliminary replicated row trial. The results for grain-yield, fodder yield as well as plant height were significant both at 5% and 1% levels. Some of the indigenous types, namely, I.C.3665, I.C.2403 and I.C.3670 were superior to Early Prodigy, I.C.1517, the standard variety, both in their grain and fodder yields.

The work on hybrid seed production with the help of cytoplasmic male sterile lines received from the U.S.A. was in progress. Eleven crosses of the promising types with the male sterile Texas Blackhull Kafir were made to study the fertility and sterility relationships of these strains with a view to utilize them in the hybrid seed production programme.

Five F1 and three F2 crosses were studied. Selections in F2 material were made for early maturity, plant height, grain colour, grain weight etc.

(ii) *Bajra;* 386 cultures including sibbed and selfed material were studied for their genetic variability. The mean flowering date varied from 38 days to 62 days after sowing. Thousand grain weight ranged from 5.0 gms. to 9.0 gms. A few strains, such as, I.C.1722, I.C.3484 and E.C.6194 were found to be bold seeded (4.50 gms.). A recent introduction, Munga potch from East Africa, was found to be promising with regard to ear-length, thickness, seed setting and seed size.

204 S2 inbreds were studied in detail and about 12 of these were found to be promising. 79 inbreds (S2) were top-crossed with T 55 for determining their combining ability.

In the top-cross trial of 39(S1) top crosses alongwith T 55, two top-crosses *viz.*, I.C. 2386/5 and I.C.1721/2 were significantly superior to T 55, the control.

54 *bajra* varieties were tested in a replicated row trial for determining their yielding capacity The results were not statistically significant. However, I.C.1732, I.C.2636 and E.C.1829 were the best yielders.

The male sterile and female sterile (Pistil-less) lines which were sibbed with their normal counterparts in sterility are recessive in F1 generation. The detailed study will be made in F2 generation.

5. Cotton

Intensive selection within indigenous lines of *G. hirsutum* has resulted in the isolation of material which appears to be very promising, especially with regard to staple length and ginning percentage. Data on the important among the selections, which are being further tested for performance in replicated progeny row trials, are given below :

Selection No.	Staple length (mm)	Ginning percentage (%)
57/S.13	30.6	32.1
57/S.16	29.0	38.2
57/S.17	30.2	37.1
57/S.18	30.0	37.1
57/S.26	32.0	28.6
57/S.27	33.2	27.0
57/S.28	32.2	29.8
H.14 (Control)	26.3	31.0

During the year under report, 152 exotic and 25 indigenous strains of *G. hirsutum*, 45 exotic strains of *G. barbadense* and 10 wild species of *Gossypium* were added to the collection. A number of the exotics were received from the U.S.A. under the Germplasm Bank of the Indian Central Cotton Committee; besides, several strains were also received from the U.S.S.R., Sudan and Australia.

In a hybrid vigour trial, the F1 hybrids of (H.14×A.C.91) and(H.14×A.C.89)gave about 25 per cent more yield than the standard variety of the tract, H.14, without any deterioration in staple length or ginning percentage.

A study was commenced on 14 *hirsutum* varieties for the determination of varietal differences in respect of characters contributing to neppiness. LL.56, a new selection from Punjab was found to be the neppiest, whereas L.S.S., also from Punjab was the least neppy.

6. Linseed

Further progress was made in the breeding of early maturing rust resistant strains of linseed. 100 promising selections were under trial. Although the results were to some extent vitiated on account of hailstorm in March 1957, a number of the rust resistant selections have appeared to be higher in yield than the standard N.P.(R.R.), New Pusa Rust Resistant, strains.

7. Pigeon-pea

Eighty six wilt resistant selections were tested for yield and other economic characters in a wilt-sick, as well as a non-wilt-sick, plot. Fourteen of these selections, in which wilt mortality ranged between 2-15 per cent. as against 26-73 per cent. in the check varieties from U.P., Madhya Pradesh and Bombay, gave remarkably good yields. Several new cross combinations were made with a view to evolving early-maturing, bold-seeded and wilt resistant strains.

8. Spices and Condiments

(i) *Improvement of essential-oil bearing plants:* This work was continued at Delhi and at the three substations at Jamnagar, Pusa (Bihar) and Katrain (Kulu valley).

A great range of variability was met with in the different crops in regard to several economic characters as will be seen from the data given below:

Range of variability

Crops	Days from sowing to flowering	No. of umbels per plant	No. of umbellets per umbel	100 seed (fruit) wt. gms.	Seed(fruit) size (length) m.m.	Single plant yield
Ajwain	68-150	14-686	9-17	0.20-0.45	2.26-3.46	1.0-31.5
Coriander	45-92	4-90	3-5	0.52-3.26	4.55-7.77	0.5-21.5
Cumin	50-91	5-80	..	0.30-0.55	4.75-5.46	0.5-8.5
Dill	60-129	4-226	13-29	0.41-0.80	4.01-6.12	1.5-47.5
Fennel	34-166	16-77	30-103	0.56-1.61	5.82-8.91	4.0-53.0

On the basis of these observations, a large number of promising selections have been made at each centre for further evaluation.

Heavy incidence of diseases, like wilt in cumin and powdery mildew in coriander and dill, was noticed at Delhi, Jamnagar and Pusa. A heavy infestation of aphids on cumin and coriander was also noticed at Delhi.

The cumin crop did not do very well at Pusa and Katrain. At Delhi, however, it did well but for damage due to wilt and hailstorm. At Katrain, coriander and *ajwain* were observed to withstand snowfall while dill and fennel were affected by it to some extent; cumin, however could not stand the cold at all.

In most of the manurial trials, it was observed last year that none of the crops responds markedly to fertilisation with nitrogen (0,10 and 20 lbs. per acre) and phosphate (0,15 and 30 lbs. per acre). The trend of the present year's results appears to generally confirm these observations; the data are, however, yet to be statistically analysed.

It was observed that the drying of the fruits (schizocarps) in shade conserves the essential oil content better than drying in sun, although the stage of harvesting also affects essential-oil content to some extent.

(ii) *Chilli:* 24 indigenous and 9 exotic cultures, the latter including 2 species of *Capsicum viz.*, *C. angulosum* and *C. astrahanskaya*, received from the U.S.S.R., were added to the collection. None of the collection under maintenance appeared to show sufficient resistance to mosaic, leaf curl and other diseases of the crop. "Puri Red" and "Puri Orange" were confirmed to be highly resistant to mosaic both in the field and under controlled conditions of infection.

9. Pasture Grasses and Legumes

146 new accessions of grasses and 20 of legumes were made during the year. In a replicated yield trial conducted with 64 strains of grasses, *Setaria sphacelata* (E.C.7431-Australia) and *Brachiaria mutica* (E.C.9715-Australia) gave the highest acre-yields (calculated) of green fodder in four cuttings—805.8 and 651.2 mds. respectively. Selfing for 2-3 generations did not appear to adversely affect seed-setting and vegetative vigour in the 21 strains of *Cenchrus*, *Pennisetum* and *Dichanthium* under study.

10. VEGETABLES

(i) *Tomato:* Hybrid vigour studies were made by comparing 33 tomato hybrids and their parents in a replicated trial. The hybrid Sioux (male-sterile) X Meeruti and its reciprocal gave the highest yields of 243 and 222 mds. per acre respectively while the combined average yield of the parents was 139 mds. per acre. The data also seemed to indicate that hybrid vigour in tomato was expressed in terms of increased yield and not in greater size of the fruits.

(ii) *Onion:* The performance of hybrid onions as compared to the parents was studied. In most of the cases, the size of the hybrid bulbs was greater than in the parents. The increase in yield over the parental lines ranged between 40-50% It may, however, be mentioned that yellow variety 'Early Grano' surpassed all the yellow and white hybrids grown from the lines imported from U.S.A.

(iii) *Peas:* F_2, F_3 and F_4 generations of various intervarietal crosses were studied and selections made. It was observed that the good filling quality of 'Early Badger' is transmitted to the progenies. Several lines superior to Early Badger in pod length and bearing were selected.

(iv) *Bhindi:* Two 5-edged selections from the crosses between 'Pusa Makhmali' and the mosaic resistant (Symptomless Carrier) 8-edged strains, appeared to show resistance under field conditions. These will be studied further.

11. VEGETABLE SEED TESTING

(i) *To fix standards of purity, germination and moisture content etc.:* Four hundred and fourteen seed samples of 45 different kinds of vegetables have been collected from various seed stockists at Delhi, Kulu, Hyderabad, Saharanpur, Bareilly, Lucknow, Kanpur, Faizabad and Allahabad. The samples tested have shown a purity range of 87% to 100%; germination 0% to 99% and moisture content 8·5% to 10%. The impurities included some of common weed seeds, other crop seeds and inert matter.

(*ii*) *Working out simple and rapid techniques for determining purity and germination :* A diaphanoscope made at the Laboratory has been found useful for purity tests.

Rapid germination tests carried out with tetrazolium chloride, sodium biselenite and malachite green have given results that conform with those obtained by germination in petri dishes and in the field. A number of cytological stains such as fast green, congo red, eosin, etc. which belong to the same group as malachite green, are being tested as rapid indicators of germination capacity of seeds.

(*iii*) *Testing and certification of vegetable seeds :* One hundred certificates have been issued for the samples received for testing from Kulu, Hyderabad and Botany Division of Indian Agricultural Research Institute.

12. GENETIC VARIABILITY IN ALGAE.

A new line of work that has been started under an I.C.A.R. scheme during the year is the study of genetic variability in Indian algae from the view point of their use in agriculture as sources of food or as nitrogen fixers. Extensive collections of fresh water algae have been made from various localities and studies on their morphology and systematic identification were conducted. Algae flora from various depths of both cultivated and uncultivated soils were studied with a view to determining their possible role in soil fertility. Some of the algae thus isolated have been found to be able to fix atmospheric nitrogen. Another interesting finding was that such nitrogen fixing algae have been detected for the first time in the root nodules of berseem.

Cytology and Cytogenetics

13. INDUCED POLYPLOIDY AS A MEANS OF CROP IMPROVEMENT

Further breeding work was carried out in tetraploids of *toria* and linseed. Cyclic crosses have been done among promising selections in tetraploid linseed and it is hoped that the hybrid combinations would show a higher degree of fertility. A comparison of the frequency of multivalents occurring in tetraploids of *toria* produced during the year and in those which were in

the C_{16} generation, revealed that a significant reduction in multivalent frequency occurred in the old tetraploids with normal bivalent pairing and full fertility by further breeding. Tetraploid berseem showed this year also superior growth in comparison with the diploids. Certain selections gave 3 to 4 times the yield of green fodder per cutting in comparison with the diploids. Tetraploid *Senji* on the other hand again showed poor growth and may not be of economic value. Tetraploids of water and musk melons were produced during the year and crosses were made between the tetraploids and diploids. The triploids thus obtained would yield fruits which have no seeds and thus satisfy one of the important demands of the consumer. Tetraploids of several ornamental plants were also produced and some of them, particularly tetraploids of Phlox, Carnations, Cosmos, Calendula and Petunia had large and more attractive flowers than the parent material.

14. Induction of Mutations in Crop plants

Mutations were induced in cotton, wheat, tobacco, potato and several ornamental plants by means of exposing seeds or seedlings to X-rays, β particles from P^{32} and S^{35}, Ultraviolet rays, fast and thermal neutrons and chemical mutagens. Among the promising mutations are (1) awned plants which are less susceptible to damage by birds in the improved but awnless wheat strains N.P. 809, N.P. 797, 798 and 799; (2) early flowering plants in N.P. 809 which might ultimately make it possible to introduce this rust resistant wheat in plains; (3) male sterile plants in Upland cotton, which promise to facilitate hybrid seed production; (4) broad leaved plants in Nattu tobacco; (5) potato plants of the Up-to-Date variety, in which the tubers show no dormancy period and which are able to grow under high air temperature conditions and (6) attractive flower variability in Cosmos, Nigella and Chrysanthemum. An interesting mutation induced by groundnut oil treatment was an awnless plant in the normally fully bearded wheat variety, Punjab C-591. Fundamental work on the factors affecting radio sensitivity in plants was done, which revealed important differences in the relative biological efficiency of the mutagens used. Treatment with P^{32} was found to induce haploidy in wheat and this effect is being studied.

15. Use of Radio-isotopes as tracers in Cytogenetic studies

A radio tracer technique was developed to study the growth of the pollen tube in the style. It was found that treatment with radio-isotopes also stimulates pollen tube growth and this effect was successfully utilised for overcoming inter-specific cross-incompatibility barriers in the genus *Nicotiana*.

16. Culture of excised plant embryos

Suitable media were standardised for the culture of jute and tomato embryos. The cross between *Corchorus olitorius* and *C.capsularis* was found to fail as a result of premature embryo abortion. It was discovered that the addition of gibberellic acid to culture media stimulates very rapid growth of young embryos. Several antibiotics, particularly Tibizide, were also found to stimulate the growth of embryos.

17. Monosomic analysis in wheat

The study of F2 of Chinese monosomes × Cometa Klein confirmed the presence of factors for awning in Chromosomes 3, 8, and 10. Segregations for resistance at the seedling stage to race H of yellow rust suggested that genes for yellow rust resistance may be situated in chromosomes 4 and 6 of Cometa Klein. Genes for several morphological characters were also located in specific chromosomes of E. 220, N. P. 790, and E. 952 by monosomic analysis. These monosomic studies are a prelude to plant breeding methods which should make it possible to transfer a particular chromosome carrying genes for some desirable characters from one variety into another variety of wheat.

Crop Physiology

18. Study of drought resistance in Wheat

Investigations on drought resistance in wheat were continued. Grain weight was found to increase at the same rate, during the first 3 to 4 weeks after dehiscence, under normal water supply and intermittent drought in spite of the fact that leaves and stems yellowed faster

and grain number was reduced under the latter water treatment. Another noteworthy point was the increase in grain size (1000-grain weight) under drought during this period. Although the water content of the leaves was considerably reduced under drought(at permanent wilting), that of the ear was not at all affected and the ear also remained completely green during this period. Subsequently leaves and stem yellowed completely under both water treatments, the ear began to turn yellow, but at a faster rate under drought, the grain size did not increase as much under drought as under normal water supply and the yield was depressed as a result under drought. During the first 3 to 4 weeks when grain weight increased at the same rate under both water treatments, it was only the ear that was completely green and later when grain weight did not increase at the same rate under drought, it was the ear that yellowed more rapidly (leaves and stem all yellow). It may be surmised that photosynthesis in the ear largely controlled increase in grain size or that the latter depends upon the rate of yellowing of ear. A variety that yielded better under drought also showed similar features of grain development. It would seem that desirable attributes in a variety for *barani* cultivation would be an ear with high grain number and long functional period.

19. Plant Hormones

In a field trial with wheats, N.P. 710 and Pb. C. 228, alpha naphthyl acetic acid spray (50 and 75 p.p.m. with wetting agent, about 4 weeks after sowing) increased the yield, though not significantly. It may be noted that the crop has lodged badly due to the hail storm in March.

In a field experiment with cotton, 216F, it was again found (in conformity with last season's observation) that NAA, IAA and IBA, when sprayed on the opening of the first flower, at 40 and 80 p.p.m., increased boll number and yield of seed cotton. In another experiment it was found that among six substances, P.C.P.A., TIBA, NAA, IBA, IAA and BNA, the last one (beta naphthoxy acetic acid) at 5 p.p.m. gave the most economic return (sprayed on the opening of the first flower).

Control of *kans* (*Saccharum spontaneum*)—CMU at the rate of 80 lbs. per acre was again found effective against *kans*.

20. Plant nutrition

In a field experiment with wheat, N.P. 718, boron application to the soil did not increase the yield as observed during the two preceding seasons. It must be noted that the crop was badly lodged due to hail storm. In another experiment with wheat N.P. 718, the five micronutrients, boron, manganese, zinc, copper and molybdenum, sprayed individually, increased the grain yield significantly by about 33%.

21. Physiological Investigations on autotetraploids of some oil seed crops: (I.C.O.C. Scheme)

The crop in the various experiments was severely damaged by the hail storm and no reliable data could be obtained.

22. Coordinated Scheme for investigations on citrus 'die back' (I.C.A.R.).

Symptoms of magnesium, iron and manganese deficiencies were obtained in mandarin under water culture.

Under magnesium deficiency, chlorosis commenced at the tip and margins of lower leaves and gradually spread over the entire lamina, leaving a wedge shaped green area at the base of the leaf. The chlorotic region later developed bronzing and dried up.

Under iron deficiency, the leaves in the apical region developed general chlorosis, the mesophyll having a light green colour and the veins a slightly deeper shade of green. The symptoms were characteristically different from those of manganese deficiency in that all the developing leaves showed the symptoms simultaneously and not progressively.

Under manganese deficiency, leaves appearing after the start of the experiment remained green and healthy for about a month; then small chlorotic spots appeared in the mesophyll tissue here and there in the oldest leaf of the new growth and in course of time, these spots enlarged and coalesced, presenting a mosaic of yellow and green. Similar symptoms appeared progressively in the upper leaves. Later the mesophyll region became uniformally yellow, the veins only retaining a light green colour. Leaves developed prior to start of deficiency retained their green colour and did not show any symptoms. Eventually growth was retarded and roots also became unhealthy. It was reported last year that the citrus orchard at the Durgapur Farm, Jaipur, which was extensively affected by mottling and 'die back', was sprayed with salts of magnesium and zinc, iron, copper and manganese in May, 1956. The trees sprayed, with zinc responded very well and the symptoms were ameliorated.

23. Plant introduction

During the year ending June 30, 1957, 2397 samples of seeds and planting materials were introduced from abroad and 740 samples were collected from within the country. A survey was undertaken with a view to collecting wild growing *Phyllanthus*, *Anona* and *Diospyros* and other material from the forest areas of the former Vindhya Pradesh. The collection of *Phyllanthus* comprised types having a range of fruit shapes, colour and si e. Some parts of the areas surveyed appeared to be rich in *Anonas*. Several large fruited types were collected from such parts. Besides, interesting material like bold seeded, early variety of *Cajanus*, vegetables including tomatoes, *Cucumis*, Chillies and other miscellaneous material such as tapioca, guava etc., were also gathered. Collections of millets and musk-melons were made from certain areas of Rajasthan and Punjab.

The material introduced during the year was varied, comprising cultivated species and allied genera of crop plants. It included wild relatives of wheat like *Agropyron* and *Aegilops*, of maize such as *Polytoca* and *Coix* besides species of *Hibiscus* , *Capsicum* and *Sorghum*. In wheat, 763 varieties were received from U. S. A. and 284 from F. A. O. Genetic stocks of cotton from Russia and U. S. A. were added to the collection. The other material introduced consisted of buck wheat, legumes, grasses, maize, oats, barley, rye, linseed, essential-oil yielding plants, vegetables including cabbage, cauliflower, turnips, cucurbits, tomato etc., water-and-musk-melons, medicinal and horticultural plants, ornamental and fruit trees.

Amongst the foreign introductions mention may be made of DARSET Sorghum from USDA, which is reported to be resistant to bird attack, sweet corn variety USDA-34, functional sterile tomato from U.S.A. and hybrid onions along with their male sterile and maintenance lines.

The material was evaluated by the respective sections dealing with individual groups of crops. The remaining material was assessed by the Plant Introduction Organisation. Following are some of the noteworthy observations.

Vegetables

(*i*) *Peas :* The complete collection of exotic and indigenous varieties was grown and assessed for two purposes, namely, as important commercial varieties and for use as breeding material. The earlier selections namely Early Badger and Bonneville were observed to be the two high yielding varieties; in addition , a few more newly received varieties also appeared promising, among t these are Early Superb from England, Morses, No. 55 from U.S.A., an Australian variety E.C. 7543 and Rimpus from Germany. Of the edible-podded varieties, the Swedish variety Sylvia was selected for further testing and multiplication.

(*ii*) *Radish :* In the rapid growing group, various strains of perennial varieties such as White Icicle, Rapidred etc., were compared and it was found that Swiss variety Eiszapzen resembling White Icicle and the Danish var. Wood's Early Frame resembling Woods Long Frame were superior to the strains now under multiplication at the Vegetable Breeding Station Katrain. These were, therefore, selected for further tests and multiplication. In the slow growing groups, the Japanese varieties were characterised by their very smooth, uniform roots and slow bolting. The older Japanese variety now under distribution was found to be the best as compared to the varieties newly received.

(*iii*) *Turnip :* In addition to the standard varieties such as P.T. White globe, Snow ball and Golden ball, three early varieties appeared promising; these were Purple top white flat from Denmark, White flat from Denmark, White flat from Japan and Milan Early top from France. These were considered worth adding to the list of varieties under distribution.

(*iv*) *Cauliflowers :* Amongst the collection of late cauliflower varieties, Snow ball was easily the best and no other could be considered even a close second. The Australian strains snowball 'A' and 'X' gave the best performance.

(*v*) *Cabbage :* The plants raised from hybrid seed of cabbage from Japan were characterised by uniform seed formation and good quality.

(*vi*) *Lettuce :* The loose leaf type *viz.*, Slobolt from U.S.A. was conspicuous by its very slow bolting but its seed production was not satisfactory under Delhi conditions. Amongst the heading types from Holland, some of the strains of 'Imperial' showed promise. These have been selected for seed production studies at Katrain.

(*vii*) *Tomato :* Amongst the newly introduced varieties of tomato, Wilt-master from U.S.A., Money maker from Holland, Groose Lisse from Australia and Akafuku No. 1 from Japan when tried for the spring-summer crop were observed to bear fruits prolifically and were selected for further trials. The tomato collection was studied for determination of total solids by the use of hand refractometer. In small cherry type tomatoes, the range was from 9 to 10% as compared to 4 to 7% in the bigger fruited varieties.

(*viii*) *Onions :* The white and yellow hybrid onions obtained from U.S.A. were compared with the standard varieties, Early grano & Pusa Red; the yellow variety Early grano was by far the highest yielder. But, however, some of the locally produced hybrids when compared with Pusa Red produced bigger sized bulbs, there being an increase of 40% in the size.

(*ix*) *Sweet potato :* As a result of trials conducted in Kulu Valley, it has been observed that the yellow and orange fleshed varieties such as Pusa Sunehri, T.O. 2442 are more suitable for cultivation on hills than in plains. There is, there fore, more scope for their introduction in hill areas. Amongst the old collections, NORIN, a red skinned variety having given good performance is now being multiplied.

(*x*) *Watermelons:* Some of the Japanese varieties such as Giant Shinyamato, Yamato Cream & Nagaoka Kohai had as high as 12% total solids whereas in the indigenous collection, the highest content was about 8% .These studies indicate that there is scope for producing better varieties from Japan. The seedless water melons introduced from Japan were observed to be seedless for all practical purposes, there being only few immature seeds.

(*xi*) *Muskmelons:* The exotic varieties did not do well since the fruits produced by these varieties were generally observed to be low in sugar content. Some of these, however, were considered important since their fruits produced a narrow seed cavity. The variety—Golden Beauty from U.K. was one such variety, which on account of its skin colour and narrow seed cavity is considered useful for hybridization purposes. The indigenous material showed a wide range of 4 to 6% total solids and as such there seems to be a good scope for selection in this material.

(*xii*) *Soybeans:* The entire collection of exotic and indigenous varieties was grown for evaluation and some for multiplication. The newly received Japanese varieties namely, Azeminori, Shakkinnarshi, Yaqi No. 1 and Rikun No. 21 looked promising as these were early, characterised by bushy growth, good bearing and bold yellow seeds. Some of the strains received from U.S.S.R. and Australia were not found suitable under Delhi conditions since they were rather late. The non-shattering types *viz.* China cluster and No. 49 having given good performance were considered to be fit for multiplication.

(*xiii*) *Cowpeas:* The collection consisting of vegetable, fodder and grain types was grown for assessment. Amongst the new introductions, varieties received from Trinidad appeared promising, some as fodders and others as vegetable types. The Brazilian varieties Potomac, Plumbco and Oscaroita were found to be fairly early having good bearing. Two varieties from U.S.A. *viz.*, Alabunch and Alacrowder appeared to be excellent grain types.

(*xiv*) *Oats:* The Oat varieties were grown to evaluate them from fodder point of view. Some of the varieties from Australia and U.S.S.R. *viz.*, 'F' C.P. 1-12736 and Adenas Amerilla, and Sovetsky, Mizazh and Tulynsky respectively were late to flower. This was considered as a desirable character since these varieties could keep green till the onset of summer and thus, the supply of green fodder be insured in the lean period.

(*xv*) *Sannhemp:* In the preliminary trial conducted with the two exotic types along with the local, it was found that the former had quicker growth and more leafy matter than the latter. They were, therefore, considered as suitable green manure types. These accessions were E.C. 1849 from Australia and E.C. 3169 from Argentina. They will be further tested and multiplied.

(*xvi*) *Castor:* Amongst the new introductions, the hybrid castor beans *viz.*, Cimarron hybrid and Hybrid-4 received from U.S.A. through I.C.O.C., appeared to have good bearing but were shattering types and the seeds produced by them were of smaller size than the local types.

(*xvii*) *Miscellaneous:* The miscellaneous collection consisted of diverse material; it included, amongst others, medicinal plants like *Rauwolfia* species, *Viola odorata*, *Matricaria* etc., economic plants like *Eulaliopsis*, Perilla etc., and many legumes and oilseeds such as Castor, *Brassicas* and *Arachis*.

24. Seed Production and Supply

(*i*) *Wheat:* As in the previous years, this Division co-ordinated the supply of the seeds of New Pusa wheats produced at the Botany and Agronomy Divisions at Delhi, A.R.S., Karnal, B.S.S., Pusa and the Wheat Breeding Sub-stations at Simla and Indore.

The demand for N.P. wheat seeds reached an all-time record, *viz.*, 13,000 maunds. Owing to the limited facilities available for multiplication of improved wheat varieties at the Institute, only 2,500 mds. of seeds could be supplied from our stocks.

The heaviest demand continued to be for seeds of N.P. 710 and N.P. 718 in the plains and N.P. 770 and N.P. 809 in the hills.

(*ii*) *Other crops:*

Crop	Quantity		
	Lbs.	Ozs.	
Oats	1333	8	
Barley	137	0	
Maize	39	0	
Arhar	8	8	
Gram	865	0	
Linseed	19	8	
Vegetables	5355	15¾	(In addtion 1603 packets of vegetables were also supplied)
Total :	7758	7¾	

25. Vegetable Breeding Sub-station, Katrain

The Sub-station continued with the large scale seed multiplication and distribution and with the various research projects aimed at breeding of improved varieties of temperate vegetables. During the year ending June 30, 1957, 3626 lbs. of various vegetable seeds were sold to various government departments, private vegetable growers and seed merchants.

Experimental: Varietal collections of cabbage, turnip, radish, carrot and cauliflower from various foreign countries were assessed at Katrain and also at Delhi. In turnip, the early and medium-ear varieties appeared very promising and these were selected for nucleus seed production for further multiplication. These varieties were 'Milan Early Red Top' from France, Purple Top from Denmark and Early Flat white from Japan. In carrot, the superiority of variety 'Coreless' selected last year was established. From the autumn-sown crop of peas collection, two semi-dwarf mid-season varieties—Yates Early crop and Lincoln showed promise. In the tall growing group, the 'Kanawari' variety (Simla *matar*) did very well. In the spring trial, Bonneville and Lincoln among medium tall varieties and Kanawari among tall varieties gave good performance.

During the summer, collections of tomato, *Capsicum*, cucurbits and beans were tried. During this period, the various improved varieties of summer vegetables evolved in the Botany Division at I.A.R.I. were also tested. It was observed that varieties of brinjal, tomato (Sioux), Bhindi, vegetable cowpea, bottlegourd, luffa gourds and Sem were equally promising for the hill conditions. The *Capsicum* variety 'Yolo Wonder' bred in America for mosaic resistance was observed to be a dwarf form of 'California Wonder' and was very healthy and prolific. The tomato variety 'Summer Prolific' did very well. The cucumber variety Long Green from Japan produced long fruits which were, however, very much less seedy from the seed production point of view. The orange fleshed varieties of sweet potato were observed to do better in the hills than in the plains.

Further testing in *inter se* crosses continued in various cruciferous vegetables for the selection of self-incompatible and cross-compatible lines for hybrid seed production. The tested plants showed various groups as determined by the alleles of the self sterility genes.

Self fertile lines were being isolated from various self-incompatible materials of cruciferous vegetable crops. The progenies of self-fertile plants selected last year were further tested and several homozygous lines have been observed.

For the improvement of quality of the Asiatic varieties of carrot, turnip and radish and to create more variability, crosses were made last year with temperate varieties. The F_1 plants were pollinated with mixed pollen by hand to produce F_2 seeds; back crosses were also made.

For improving the stock seed of the varieties of cabbage, turnip and Knol Khol now being multiplied, selected plants from selected inbred lines were open-pollinated under the cage through the agency of bees for the selection of lines of high potentialities.

In Knol Khol, selections were made last year of plants with various types of seed stalk branching and seeds produced by controlled pollination. These were observed to be genetically controlled types. Selection is being pursued with the aim of producing high seed yielding types of superior quality.

The seed of snowball—16 cauliflower produced at Katrain last year gave at Delhi a performance just as good as that of the original seed. The Japanese early variety of turnip when grown at Delhi from the Katrain produced seed, gave better performance than from the original seed.

26. Botanical sub-station, Pusa

The crop season at Pusa was unfavourable to the crops in general due to uncertain weather conditions throughout the year. In spite of a total rainfall of 41·99 inches during the year, the *Kharif* crops suffered due to unusual dry spells during the months of July and August and

the unexpected heavy downpour at the time of maturity during September and October. The growth of the late-sown *rabi* crops was hampered due to early onset of hot winds in February which adversely affected the seed formation of these crops.

Work on the improvement of different crops *viz.*, Cereals (Wheat, Oats, and Paddy), Pulses (Mung, Urid, Lentil, Rahar, Soybeans, Khesari & Gram), Oil seeds (Seasamum, Linseed, Safflower & *Brassica*), Fibres (Sannhemp, *Hibiscus*, Jute), Vegetables (Chilli, Tomato and Pea) and Narcotics (Tobacco) was continued according to the approved programme. In addition, the Divisions of Chemistry & Entomology were provided facilities for conducting some of their experiments under local conditions of soil and climate.

In wheat, there was a very mild attack of yellow rust and a moderate attack of brown rust. The attack of black rust was, however, very severe. Various N.P. wheats under distribution were multiplied on a large scale and seeds distributed. The yield trials of promising Oats (*Avena* spp.) material gave results in conformity with those obtained last year. Exotic varieties like Abundance, Reed-19 &19A etc., have done well and will be tested on a large scale next year. For the second year in succession, the Mung (*Phaseolus radiatus*) Variety N.P. 23 (control) has established its superiority over the rest of the varieties tested in trials. The trial with the later maturing China variety No. 781 received from Bombay had to be abandoned this year. This variety will be tested against N.P. 23 and Local under irrigated conditions next year. Urid (*Phaseolus mungo*) crop this year was completely destroyed by a heavy attack of hairy cater-pillar (*Amscata moria*) and unfavourable weather conditions. Yield trials with wilt resistant Rahar (*Cajanus cajan*) types showed the superior performance of C-15 W.E. and C-38 both as regards yield and resistance to wilt as compared to the control, N.P. 41. Some of the Bihar types B.R. 5, 34 and 65 have yielded well in spite of heavy wilt infection and have additional advantage of early maturity to the extent of nearly two months. Amongst the Khesari (*Lathyrus* spp.) varieties tested, exotic varieties E.C.5, E.C. 413 E.C. 804 and E.C. 1863 and indigenous collections, I.C. 75 and I.C. 77 have given promising results for the yield of fodder. Extracted types from the corss *Seasamum orientale* × *S. prostratum* tested for the fourth year in a replicated trial, have again shown inconsistency in yield. The yields of these types are poor; they are fairly early and are not suited to this tract. The exotic type, Nebraska 852 of Safflower (*Carthamus tinctorius*) topped the list of the varieties tested for yield against N.P. 30, yielding 310 per cent higher than the control. The yields, in general, have been low this year due to the varieties being badly attacked by a virus disease. For the second year in succession, the autotetraploid strain of *toria* has out-yielded the local diploid variety of *sarson*, the yields being 383 and 100 per cent respectively. Exotic Jute (*Corchorus capsularis*) type E.C. 4142 has all along been outyielding the rest of the varieties in fibre yield and repeated its performance during the year by giving 170 per cent more fibre yield as against the control D-154. In *C. olitorius*, J.R.O. 632 appears to be the best amongst all for the yield of fibre. Amongst the seed types, D-154 and J.R.O. 620 continued to show promise for the tract. All the nine early pea types *viz.*, Early June, Bonneville, Deliviche commando, Table-19 and Mahendorfer have given higher yields than the control. All the types, however, were badly attacked by pea rust, *Uromyces apendiculatus*.

Maintenance of indigenous and exotic collections and of nucleus seed of improved varieties in a number of crops was continued. In addition, over 800 mds. of pedigree seeds of N.P. types of different crop plants were produced out of which about 343 mds. were distributed during the year among the different State Departments of Agriculture and private cultivators.

The other Divisions of the Institute conducted their experiments for the second year on the use of Dicalcium Phosphate and Kotka Phosphate on wheat, the permanent and the New Manurial *cum* Rotational Experiments, and work on the survey and control of insect pests.

Programme of work for 1957-58

1. Improvement of Indian wheats with special reference to breeding varieties resistant to the rust, smut and bunt diseases and to drought and lodging.

2. Study of the suitability of N.P. wheats and other breeding material to different agronomical conditions.

3. Genetics of rust resistance and other characters in wheat.

4. Study of the milling, baking and *chapati*-making qualities of Indian wheat.

5. Breeding for rust and smut resistance in barley.

6. Breeding for rust resistance and earliness in linseed and wilt resistance and earliness in pigeon-pea(*arhar*).

7. Breeding extra-long staple varieties of cotton.

8. Trials with the recently evolved N.P. strains of crop plants such as wheat, linseed, pigeon-pea, tomato, etc., in the different States of India.

9. Trials with foreign varieties and foreign and indigenous inbreds and hybrids of maize on a regional basis in India.

10. Investigations on the utilization of hybrid vigour in various crop plants including maize, *jowar*, *bajra*, tomato, onion, *bhindi*, radish and cotton.

11. Breeding for high yield and early ripening in fodder and grain types of *jowar* and *bajra*.

12. Breeding of some pasture grasses and legumes for northern India.

13. Study of the wild relatives of crop plants and their utilization in plant breeding with special reference to wheat, *bhindi* and *Seasamum*.

14. Improvement of chilli by breeding disease resistant varieties.

15. Improvement of some essential-oil bearing plants.

16. Breeding varieties of poppy with high and low alkaloid contents and high yield of *khas khas* seed.

17. Breeding superior varieties of water melon and musk melon.

18. Breeding of vegetables, including the European type vegetables such as cabbage cauliflower, turnip, etc., and development of improved methods for the commercial production of quality seed in them.

19. Improvement of ornamental plants by the application of modern techniques like induction of polyploidy and mutations.

20. Study of the genetic variability in Indian algae with a view to their utilization in agriculture.

21. Testing and certification of seeds of vegetable crops.

22. Induction and study of polyploidy as a method of crop improvement in oleiferous Brassicae, linseed, berseem, etc.

23. Cytogenetical studies in various crop plants including oleiferous Brassicae, linseed, *Sesamum*, wheat and allied genera.

24. Monosomic analysis of rust resistance and other characters in wheat.

25. Cyto-taxonomical and cyto-ecological studies in some Indian fodder grasses.

26. Induction of mutations in crop plants through the use of chemicals, radiation from radio-active isotopes, neutrons, x-rays and ultra-violet rays.

27. Studies on the incidence and induction of pollen sterility in crop plants.

28. Application of embryo-culture technique to overcome embryo lethality in distant crosses.

29. Improvement of cytological technique.

30. Physiological studies on resistance to drought and lodging in wheat.

31. Physiological analysis of factors concerned with yield in wheat.

32. Influence of light and temperature on growth and development in wheat.

33. Physiological aspects of plant nutrition in wheat studies on the relation between varietal differences in the uptake of nutrients.

34. Plant hormones—investigations on their role in growth and development in wheat, cotton etc., and their use as weedicides.

35. Plant physiological studies in relation to the die-back disease of citrus.

36. Plant physiological studies on colchicine-induced autopolyploids of oil-yielding plants such as *toria*, linseed, etc.

37. Plant introduction and collection of indigenous plants of economic value; their maintenance, evaluation and trials at Delhi and other places.

38. Multiplication and distribution of pure seeds of improved N.P. varieties of field and vegetable crops.

REPORT OF THE DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

(Dr. S. P. Raychaudhuri)

A. Agricultural Chemistry

(a) Soil Fertility :

1. *Cow dung gas plant :*

The dual purpose cow dung gas plant for gas and manure has been installed in ten villages around Delhi for the use of farmers. Certain modifications have been made in the plant to introduce leaves, straw and other wastes into the fermentation tank. The quantity of gas obtained by fermenting dry leaves has been found to be about 7 cu. ft. per lb. of dry leaves.

2. *Effect of sodium on nitrogen fertilized wheat :*

Sodium chloride at 80 lbs. Na_2O per acre applied with 40 lbs. N as ammonium chloride or ammonium sulphate, showed an additional response of 20—25 per cent in grain yield, with no increase in the yield of straw. The beneficial effect of sodium was also evident from an increased yield of grain of 20 per cent over 200 lb. N as compost. Potassium chloride at this dose gave no response which indicates that the effect is specific for sodium which mobilizes fertilizer and organic manure nitrogen for grain formation.

3. *Processing of bone and indigenous rock phosphate :*

(i) Whole bones have been found to disintegrate completely when immersed in 10% caustic soda solution for about 3 weeks. A fine bone meal containing 27% total P_2O_5 of which 86 per cent was in available form, was obtained by washing the material free of caustic soda and drying the product. Further studies showed that this could be achieved by 2·5% caustic soda solution to which 1% sodium chloride is added.

Bones could also be disintegrated by partial charring in the fire or in heated sand.

(ii) Whole bones have been found to dissolve in 10% HCl in about a week. This when treated with ammonia or KOH yielded products containing 10% P_2O_5 in available form. The former product contains 11·4% N in addition.

(iii) Raw bone meal when processed by fusion with ammonium sulphate and ammonium sulphate nitrate yielded fertilizer products containing 16% N and 7% P_2O_5 of which 70 to 80% is in available form.

(iv) Finely ground Trichy rock phosphate processed by fusion with ammonium sulphate, sulphate nitrate, sodium nitrate, yielded compound fertilizer products of over 60% ammonium citrate solubility of the total P_2O_5.

(v) The above fertilizer products were tested in pot experiments on wheat and significant effect on the yield was observed. There was evidence of higher availability of P_2O_5.

4. *Studies on the availability of nitrogen in fermented bulky organic manure :*

Treatment of compost with NaOH, CaO, $CaCO_3$, H_2SO_4, HNO_3 and $KMnO_4$ have indicated the possibility of increasing the available nitrogen in such manures.

5. *Placement of fertilizers :*

In field experiments on calcareous soil at Pusa, placement application of *Kotka* phosphate gave 28% increased yield of wheat as compared to 20% obtained with superphosphate. The response was reduced to 18% and 12% respectively when the fertilizers were broadcast.

9—1 I. A. R. I./57.

6. *Comparative study of the indicator plant method, Mitscherlich method and Neubauer method for finding the major nutrient deficiencies in the alluvial and black soils :*

For culture experiments on potato with different combinations of N, P, K such as, N at 0, 75, 125 and 175 ; P at 0, 40, 80 and 120 and K at 0, 30 and 60 lbs. per acre were done. With I. A. R. I. Farm soil, visual deficiency symptoms of N and P_2O_5 appeared in the treatments which do not include these constituents. Definite response in the yield of tubers was also noticed with addition of N and NP.

7. *Fertility status of Acid Soils :*

The study of the fertility status of acid soil collected from West Bengal, Coorg, Mysore, Travancore and Assam, is in progress. Experiments have been devised to simulate the conditions in the root zone of the plants by putting the soil in semi-permeable parchment bags and dipping these bags in different phosphate extracting solutions, to test the methods for determining the available phosphate.

8. *Carbon and Nitrogen status of semi-arid and arid soils of India :*

Soil samples from Delhi, Rajasthan, Saurashtra & Punjab have been analysed for their carbon and nitrogen contents and the variations in C N ratios and organic matter status of those areas have been evaluated.

(b) Microbiology :

9. *Effect of inoculation with nitrogen fixing organisms on the yield of wheat, paddy and rahar :*

Inoculation of seeds of *rahar* with Azotobacter from *rahar* leaves, with rhizobium from *rahar* root nodules and with a mixture of the two failed to improve the yield of the grain.

10. *Activation of Azotobacter with and without cellulose decomposing organisms :*

Strain variation in Azotobacter population of different soil localities was studied. It was observed that the strain could be differentiated from each other on the basis of their ability to utilise peptone, benzoate, dextrin and starch and on their tolerance of acid, alkali and salt.

In some soils, the differences between the nitrogen fixing capacity of different strains from the same habitat were not significant, in some others the differences were statistically significant for most soils, the deviation in nitrogen fixing capacities of individual strains from the average of all the strains in a single soil were not very large.

11. *Studies on rhizobium of wild leguminous plants :*

An organism was isolated from the glands of the non-nodulating legume *Cassia occidentalis* which possessed characteristics somewhat similar to phosphorbacterium (Fosfo 24) from Czechoslovakia. It brought into solution appreciable quantities of phosphorus from insoluble inorganic and organic phosphate in presence of combined nitrogen. Both the *Cassia* organism and Fosfo 24 differed from phosphobacterin (U.S.S.R.) organism in their inability to produce ammonia from nitrogenous compounds though they made free use of the nitrogen in the combined form. Inoculation of pea with a culture of the Cassia organism resulted in significantly higher yield of the crop in Delhi soil.

Effect of growing summer legumes on the carbon and nitrogen content of soil was also investigated. Wild legumes were observed to differ among themselves in their capacity to act as soil renovating crops. *Desmodium purpureum* and *Tephrosia purpurea* were not found to be very suitable as they did not increase either the carbon or the nitrogen contents of the soil. *Crotalaria mucronata* and *Sesbania aculeata* increased the organic matter content and *Cassia occidentalis*, *Clitoria ternata* and *Phaseolus lathyroides*, increased the nitrogen content of the soil *Dolichos lablab* and *Mucuna capitata* improved both the nitrogen and carbon content of the soil.

12. *Studies on the characteristics of Rhizobium japonicum :*

The efficiencies of different strains of *Rhizobium* japonicum were found to be positively and significantly correlated with their power of consumption of glucose in artificial culture.

13. *Effect of different phosphates on nitrogen fixation by guar (Cyamopsis psoraloides) :*

The strains of rhizobium isolated from *Guar* treated with superphosphate and bone meal possessed higher nitrogen fixing capacity.

Evidence was also obtained of definite excretion of nitrogenous substances from the roots of the legume in the soil. The total nitrogen fixation as well as excretion both increased as a result of treatment of the soil with superphosphate. The amount of excretion varied from about ten to twenty per cent of the total nitrogen fixed by the plant. Phosphate treatment was not found to alter the proportion of excreted to fixed nitrogen in an average soil. The excretion was depressed in soils poor in nitrogen as a result of the phosphate treatment.

14. *Nitrogen fixation in Indian soils in relation to phosphate availability :*

Nitrogen fixation observed in mannite solution in the soils had no relationship with total or available phosphate content as determined by acid and alkali extraction methods. Nitrogen fixation in soil medium, however, was found to be positively and significantly correlated with the total and available phosphate content as determined by Dyer's method of extraction with 1 percent citric acid only.

15. *Effect of gypsum on moisture retention and nitrogen transformations in soils :*

Retention of moisture by a non-alkaline soil was not affected by application of 1 ton or 5 tons or gypsum per acre. Treatment of normal soil with gypsum might depress nitrification particularly when the soil was treated with large quantities of organic matter like farm yard manure. Heavy application of gypsum to a soil treated with large quantities of low nitrogen materials might induce denitrification. Large quantities of nitrogen was fixed however, when the soil was treated with large quantities of high nitrogen material like legume litter.

16. *Microbiological decomposition of herbicides M. C. P. A. (Methyl-chlorophenoxy acetic acid) and 2—4 D (Dichlorophenoxy acetic acid) and their effect on microbiological activities in the soil:*

These herbicides at a concentration of 1 to 5 p.p.m. did not interfere with nitrogen fixation in culture media. 2—4 D when added to the soil at the different rates varying from 1 to 15 lb. per acre did not interfere with nitrification of soil nitrogen or nitrogen added in the form of sulphate of ammonia.

B. Soil Survey and Soil Physics

17. *Studies on the properties and formation of black soil as affected by parent rocks :*

The black soils occurring on diverse types of parent materials were studied chemically, physically and mineralogically. Basaltic soils from Australia were also compared. The black earths of Australia, are similar to black soils of India with certain differences in chemical properties and also in cation exchange property *viz.* the Ca/Mg ratio in Indian soil is 5·67 to 9·71 while that of Australian soils is 0·57 to 1·18.

18. *Red and laterite soils :*

In continuation of the work reported earlier, the morphological and chemical studies were extended to laterites and associated soils of Travancore and Cochin. The native rocks are biotite gneiss, charnockites and granite gneisses. Three groups of soils have been identified, the Brown Forest Soils, the laterite and red soils of loamy and sandy texture. The Brown Forest soils showed a weak podsolic nature. The laterites are of detrital nature; the vesicular structure is weakly expressed. The red soils are of alluvial origin with no sesquioxide concretions within the profile. Chemical studies confirmed the

disguised podsol features of the Brown Forest Soils. Chemical data on the laterites showed that secondary changes are taking place in the laterite areas and the surface soils are losing sesquioxides under podsol type of leaching. A classification scheme has been worked out to include the laterites and related soils.

19. *Alluvial Soils :*

To understand the morphology and genesis of the alluvial deposits laid down by rivers, morphological, physicochemical and mineralogical studies of arid and semi-arid soils in West Uttar Pradesh were taken up. Morphological features revealed horizon differentiations on the basis of texture, drainage and occurrence of lime. The normal cultivated soils showed pH ranging from 6·7 to 9·0, low conductivity, and clay content of 10 to 45%. The maximum cation exchange capacity was 18·7 m.e./100 gm., with Ca as the predominant exchangeable cation. Clays had SiO_2/R_2O_3 of 1·5 to 2·37. The alkali soils occurring close by had high pH, high conductivity with sodium as the predominant cation and carbonate and bicarbonate as predominant anions. Exchangeable Na constituted 20 to 95 per cent with a high Sodium Adsorption Ratio.

20. *Studies on Black soils of India :*

Black cotton soils, two profiles formed from trap rock, at Achalpur (Bombay) and two profiles of the same found on limestone, at Labhandi Farm, Raipur (M.P.) have been studied for their morphological, physical & chemical characteristics. The main crop in the former region is cotton while that in the latter is rice. In the trap area the upper horizon is either of grey or dark grey to a depth of 24 to 30 inches, underlain by brownish horizon of *murrum*. Lime concretions are present throughout the profile. Clay content varies from 47 to 22 per cent and variations in the physical constants are : water holding capacity 57 to 32 per cent ; lower plastic limit 39 to 25 per cent and liquid limit 80 to 47 per cent. In the limestone region the soil is olive-gray coloured up to a depth of 84 inches changing to brownish colour. The brownish horizon (parent material) occurs at a depth of 54 inches in high level topography.

21. *Soil Conservation studies : Runoff experiments :*

With the object of studying runoff and soil loss, four runoff plots (each measuring 50 ft. × 5 ft.) have been laid out along with the collection tanks for measuring soil loss and runoff. The cropping patterns will be fallow, grass, fallow-wheat and *Bajra*-fallow. An automatic rainfall recorder and an U. S. A. type Open Pan Evaporimeter have been installed near the runoff plots for measuring rainfall and evaporation.

22. *Soil Moisture Studies :*

(a) Seasonal soil moisture fluctuations on I. A. R. I. Farm area showed that some of the high lying soils (*e.g.* Main Block plot 3 and Shadipur B) dried to wilting points in drought period between March and June, 1957.

(b) *pF of soil water :* At constant pF value (3·0), different soils gave different field capacity moistures :—

sandy soil 3; loamy soil 22; and clay loam 29.

(c) *Soil Moisture under Ley Farming :* Soil moisture holding power was doubled (3% to 6%) in grass laid plots at the top block area at the I. A. R. I. Farm.

23. *Soil structure :*

(a) Under ley farming studies it was observed that the deep rooted grasses produced better soil crumbs than shallow rooted.

(b) *Soil conditioners :* In the pot experiments on an alkali soil with pH of 9·2 gypsum and krilium combined have given the maximum yield of berseem. The aggregate analysis and pH value which has gone below 9·0 by the application of gypsum show that the increase in yield was due partially to the improvement in structure and partially because of the replacement of Na† by the Ca††ions in the exchange complex.

(c) *Permeability studies :* Percolation capacity of soils was directly proportional to the non-capillary pore space. Undisturbed soils showed greater infiltration rate.

Large size permeameters gave more reliable data while examining soil permeability.

24. *Studies on saline and alkali soils :*

Reclamation of saline and alkali soils in Delhi villages : On alkali soils with pH at 9·0 or above, it was found that the application of gypsum at the rate of 2 tons per acre and organic refuse at the rate of 4 tons per acre had resulted in better crop growth and the wheat grain yield was increased by more than 100%.

C. Physical Chemistry

25. *Studies on the formation of saline and alkali soils of Pusa and their reclamation :*

The four electrode method of measuring soil resistivity in the field has been introduced for the quick location of the impervious sub-soil layers as well as the water table without the necessity of digging many pits. The field soil resistivity profiles at Pusa fell into four main categories; those with values gradually decreasing with depth upto the water table, characteristic of the well drained soils ; those with these values gradually increasing with depth characteristic of the saline soils ; those with these trends broken by a considerable range of nearly constant values in the middle indicating a highly dispersed impervious moist sub-soil characteristic of the alkali soils ; and lastly those with an increasing trend intercepted by sharp breaks characteristic of the calchie pan layers of the normal Pusa soil. As the moist impervious layers in the alkali profile during summer months extended up to a depth of 5 ft. open drains have been dug upto a depth of 5 ft. and reclamation work has been started on an experimental measure with levelling, gypsum, flooding, legumes and sugarcane or rice, heavy irrigation at long intervals and gypsum additions in between monsoon leachings.

26. *Studies on the suitability of irrigation waters for different soils :*

The total salt content, the ratio of sodium to calcium or calcium plus magnesium and the amount of toxic elements have only been so far considered in determining the suitability of irrigation waters. Work done here has shown that the nature of the soil to be as important. At a constant ratio of calcium to sodium in milliequivalents of 1 : 1 and at a total salt content of 1-N, the different soils had an equilibrium sodium saturation of their exchangeable complex varying from 71 to 24% and their clay dispersed to the extent of 26 to 6% depending on the nature of their dispersible material.

27. *Physico-chemical studies on the fertility of soils due to their clay-humus complexes :*

The infertile plots of the middle block C_1 and C_2 which did not give a significant response to wheat with artificials were found to have less amount about 11% of Tuylin's Clay-humus complexes of Group I as compared to the fertile plots 13-D of the main block which gave a response and which had consistently higher values for this complex of the order of 12%. The percentage of clay aggregated in the former was also less being 85% as compared to 90% in the latter. This fertile group was produced in the order bentonite greater than illite greater than kaolinite >silica> iron oxide when they were composted with F. Y. M. Amongst the organic manures berseem was equal to F. Y. M. which was greater than groundnut cake in their capacity to produce these complexes with bentonite. It was also found from laboratory experiments that bentonite could be substituted by the black soil from Padegaon in increasing this fertile complex in composts with F. Y. M.

28. *Physico-chemical studies on frost-resistance in arhar:*

The results of this year have confirmed the previous years finding that the frost-susceptible varieties of *arhar*, Guntur 2 and E. B. 3 had lower electrical conductivity in their leaf juices than the resistant varieties N. P. (W.R.) 38 and UP 17—2. The former also retained less water at higher tensions than the latter showing that they contained less hydrofilic material.

29. *Studies on the anion exchange capacity of Indian soils* :

Different methods of determining anion exchange capacity of calcium saturated soils were compared. The one using M/3 sodium phosphate at pH=4·0 as the saturating solution and M/2 sodium arsenate of pH=4·0 as the displacing solution was found to differentiate the soils by the nature of their soil clays. Pusa and Cinchona soils had the highest values of about 138 m.e./100 grams of the clay and Karnal soil 103 while the red and black soils of the Deccan had 89 and 80 m.e. respectively. Available methods are being modified with a view to reflect, if possible, the PO_4 supplying power of the soils.

30. *Studies on the interaction of soil clays and clay minerals* :

The interaction between bentonitic clays and illite reported last year from measurements of surface area, cation exchange capacity and moisture retention of mixtures of the isolated clays has been confirmed by studying the electrical conductivity and exchange acidity of the mixture of their clay-soils.

31. *The mineralogical analysis of soils and clays* :

Work was undertaken to find out any correlation with "Y" values and the mineralogical composition of clays. Clays were isolated from soils of Indore, Madhya Pradesh, Delhi and also ten more from soils collected by the T. C. M. project. Mineralogical analysis of clays reveal that clays from arid tracts, *e.g.* Delhi and Karnal are dominantly illitic with traces of kaolinite ; black cotton soils, from Indore containing a mineral montmorillonite alum as dominant constituent with traces of illite and kaolinite, while those from Aduthurai and Akola contains mostly of montmorrillonitic type of mineral with little or no illite and trace of kaolinite.

Some clays collected from different altitude in Kashmir were analysed for mineralogical make up. These clays consisted mostly of kaolinite, possibility of Halloysite was indicated and of illite in fair amounts. Detailed examination to be taken up.

The correlation work with "Y" values is in progress.

D. Plant Chemistry

(a) Organic Chemistry :

32. *Organic thiocyanates :*

In continuation of the work reported earlier about two pounds each sample of longifolyl, nopyl and isobornyl thiocyanoacetates were prepared. Their toxicity was tested against mustard aphids *Lipaphis erysimmi* and promising results were found. Longifolyl thiocyanoacetate prepared from soild isomer of longifolyl alcohol showed lower toxicity as compared to longifolyl thiocyanoacetate prepared from the liquid fraction of the alcohol. This possibly suggests the role of molecular structure *vis-a-vis* toxicity in organic compounds.

33. *Chlorinated insecticides :*

Chlorinated carene fraction with 50—52% chlorine content, undergoes dehydrochlorination with alcoholic caustic potash at 0^0 and $36·5^0$C to about the same extent as DDT and to a greater extent than Toxaphane. This property may have to do something with the toxicity of chlorinated carene fraction.

34. *Synergists for insecticides and insecticidal formulations :*

Using turpentine oil obtained from Bareilly Rosin & Turpentine Factory through National Research Development Corporation, collaborative pilot plant investigations were taken up at Shri Ram Institute for Industrial Research at Delhi for the production of terpene alcohols and ethers (synthetic pine oil). The conversion of the terpenes to alcohol and ethers on pilot plant compared favourably with the results obtained in the laboratory. Further work is being continued.

Sesqui-terpenes obtained in connection with the preparation of longifolyl thiocyanoacetate showed larvicidal action against *Culex fatigans* larvae. However, the film on water was not stable and the spreading power was also poor. Further work is continuing.

35. *Fungicides* :

A compound, analysing to glycerol dithiocyanoacetate has been prepared, starting with glycerol. Contrary to expectations, it did not show toxicity as a contact poison against *Tribolium castaneum* and as stomach poison against 5th stage locust hoppers. However, the material possesses reasonably good fungicidal properties.

A Ketone ($C_{10}H_{16}O$) obtained by the oxidative degradation of unreacted sesquo-terpene obtained in connection with the preparation of longifolyl thiocyanoacetate, possesses fungicidal properties and was found to be toxic both against mycellium as well as spores.

36. *Pyrethrum :*

Observations with five samples of pyrethrum flowers indicate that there exists a linear relationship between the total alkali consumed by the flower extractives and total pyrethrin content of the flowers. Further confirmation of these indications should provide a valuable method for mass screening of pyrethrum strains in breeding work.

37. *Development of antioxidant for edible oils :*

It was reported earlier that oil soluble resin fraction obtained from the seeds of *Myrestica malabarica* showed promising antioxidant activity for oils and fats. Preliminary experiments indicated the presence of toxicity when fed to adult rats at 7% level of the total extract. Attempts to purify the material have not met with success. The antioxidant cannot be recommended for edible oils or fats.

38. *Scheme for the improvement of essential oil yielding spices of India* :

The British Pharmacopea method with certain modifications is being used for the estimation of volatile oil in spices. Attempts for developing a rapid method as an aid for plant breeding work are being made.

(b) Biochemistry :

39. *Quality of wheat as affected by the spraying of urea solution :*

Experiments conducted in the field have confirmed the earlier findings that foliar application of dilute solution of urea at the time of flowering significantly increases the yield and protein content of wheat grains. Spraying more than once does not seem to significantly affect the yield while the protein content is progressively increased. The increase in protein is also accompanied by an increase in the phosphorus content of the grain. Mottling of the grains was also very significantly reduced. The nicotinic acid content of the grains has also been found to have considerably increased by foliar application of urea.

40. *Quality of wheat as affected by micro-element fertilizers :*

Experiments carried out in pots to study the effect of foliar application of copper, manganese, zinc, magnesium and their combination on wheat mostly confirmed the results of the field experiment reported earlier. The increase in grain yield observed on account of these sprays was primarily due to the increase in the number of fertile spikelets in the ear. It was found that spraying of all these elements was conducive to a greater synthesis of protein in grains. It was also found to have increased the phosphorus and calcium content of the grains. Among soil treatments, maximum response in yield and protein was obtained by manganese. In the case of foliar treatments zinc proved to be the best. The effect of microelements on the yield and protein content of grains was consistant for all the three years during which this experiment was conducted.

41. *Biological value of pulse proteins :*

The protein efficiency ratio and the biological value of proteins in *Arhar* and *Urid* can be significantly increased by supplementation with methionine, lysine and vitamin B_{12} but not by threonine and tryptophane when fed to rats at 12% protein level. The availability of methionine, tryptophane, threonine and lysine in *Arhar* increases with the supplementation of respective amino acids. The excretion of total amino nitrogen in the urine of rats was maximum with supplementation of methionine followed by that of lysine, threonine, tryptophane and vitamin B_{12} when *Arhar* was fed.

42. *Enzymic digestibility of pulse proteins :*

Pancreatic digestion of plant proteins in gram, *mung*, lentil, *arhar*, *urid* and pea was compared with that of casein and meat. The digestibility as measured by formol titration was found to be the maximum in the case of meat followed by that of casein, gram, lentil and pea while that of *arhar*, *mung* and *urid* was the least. The *invitro* digestibility of protein varied considerably among the different pulses, that of gram being the best. The number of enzymatically released amino acids estimated chromatographically was more in the case of animal proteins as compared to those of plant proteins.

43. *Free amides and amino acids in berseem :*

Berseem plants, grown in the field with superphosphate and molybdenum, were drawn out at different periods of growth and the various tissues, such as, leaf, stem, root and nodules were analysed. Aspartic acid, glutamic acid and serine were the predominating free amino acids in all the tissues throughout the growth period. Asparagine was found to occur in greater concentration as compared to glutamine. The mechanism of synthesis of asparagine and glutamine is being studied.

44. *Urease in wheat leaves :*

In order to find out the mechanism by which urea-nitrogen is utilized in the plant when sprayed on the leaves, the presence of urease in wheat leaves was studied. Urease was found to be present in both young and mature leaves. A partially purified enzyme was prepared from wheat leaves and its kinetics were studied. The enzyme is heat labile. It is specific for urea and does not attack biuret. Its activity is highest at pH 7·5, and is inhibited largely by sodium fluoride and cystine.

45. *Chemical composition and nutritive value of Indian wheat :*

The third year's crop grown in replicated plots at Delhi and Pusa was analysed for its chemical constituents.

E. Physics

46. *Spectrographic methods of analysis :*

(a) *Direct current arc techniques :* Direct current arc methods of estimation of microelements in plant and soil samples developed earlier, are being modified as to include measurements of some major elements like calcium, magnesium etc. Boron and manganese contents in over ninety samples of citrus leaves varied between 24 to 350 p.p.m. and 1·1 to 92·1 p.p.m. respectively.

(b) *Use of Electrolytic copper as electrode material :* Spectroscopically pure copper electrodes are being used in the Direct Current Arc Methods of estimation. As these are to be imported from abroad and not easily available in our country possibility of using commerical electrolytic copper wire as electrodes material is being examined.

(c) *Lundegardh Method of estimating major elements :* Using this method about 110 samples of citrus leaves were analysed for potassium, calcium and magnesium, the values varying between 0·28 to 2·85%, 0·7 to 5·63% and 0·15 to 0·85% respectively.

47. *Estimation of iron and zinc in plant material :*

A routine method for the estimation of iron in plant material was standardised using U. V. Speek Spectrophotometer. During the process optimum conditions for colour development were deduced and the method of scott was suitably modified. The Fe_2O_3 content of about five dozen samples of citrus leaves varied between 92 to 400 p.p.m. Using the Polarographic technique about 88 samples of citrus leaves were analysed for zinc content which varied between 1 to 6·5 p.p.m.

48. *Electron microscopic studies of Plant viruses and clays :*

Laboratories for the study of the physical properties and other problems on plant viruses, clays etc. using electron microscope are being equipped. The individual parts of the Phillips Electron Microscope were tested.

49. *Qualitative identification and quantitative estimation of clay minerals by X-ray diffraction method :*

A Phillips X-ray diffraction unit is being set up for work on clays.

F(a) Soil Testing

50. *Estimation of available nitrogen in soils by different methods and correlation with crop response :*

Soil from different agronomic trial centres, having known crop response data on paddy and wheat, were analysed for available nitrogen by three methods—(i) alkaline permanganate method, (ii) rapid Iowa nitrification method, and (iii) Richardson's modification of Olsen's method and their values were correlated with the percentage yield response. The results of pot culture experiments with paddy and some data on *Bajra* crop of the fertilizer experiments conducted in the Delhi State villages were also correlated with crop response.

The available nitrogen as estimated by the alkaline permanganate method gave correlation significant at 5% level for wheat, paddy and *Bajra*. The Iowa rapid nitrification method gave no correlation with paddy but it gave significant correlation in the alluvial soils of Delhi for wheat and *Bajra*, Richardson's modification of Olsen's method gave no significant correlation in any of the soils.

51. *Determination of available potassium by different extractants and correlation with crop responses :*

Soils from different agronomic centres were analysed for available potassium with the help of Flame Photometer by using different extractants such as, (i) 1% citric acid, (ii) Normal amonium acetate, (iii) 0·5$NHNO_3$ (2 hour heating at 95°C), (iv) 0·5N HNO_3 ($\frac{1}{2}$ hour shaking) and (v) Morgan's Universal extractants and the values were correlated with the crop response. Most of the correlation coefficients are not significant. None of these methods gave consistant correlation with all the soils. The correlation co-efficients were significant with nitric acid extractants in the soils of Mangalore (Coastal alluvium) and Raneswar Block soils with paddy and with 1% citric acid in the case of Simla soils.

52. *Examination of suitability of four soil test kits such as I. A. R. I., Purdue, Spurway and Morgan :*

A number of soils were analysed for available P_2O_5, available K_2O and pH by all the four test kits.

A method for the estimation of pH of soil colorimetrically was developed for the I. A. R. I. test kit. The methods for the estimation of available P_2O_5 and K_2O by I. A. R. I. test kit were also standardised.

F(b) Radiotracer Investigations

53. *Phosphorus fertility status of soils, radiotracer and related investigations :*

(a) *Available phosphorus in soils and phosphorus fertilizer utilization by rice, wheat/oats; a greenhouse-cum-laboratory study with radioactive superphosphate :* During the year, two crops, paddy (Var. NP 130) and wheat (NP 718) were grown in the greenhouse for the study of the utilization of fertilizer phosphorus. 9 different soils in the case of paddy and 6 soils in the case of

wheat were used. The soils were treated with radioactive superphosphate. In paddy, seven out of nine soils responded to phosphorus application—the percentage yield response varying from 26 to 87. In wheat, four out of six soils responded—the percentage yield response varying from 36 to 83. In paddy, percentage uptake of fertilizer phosphorus varied from 12 to 90 and percentage phosphorus fertilizer utilization from 0·4 to 28. In wheat, the same values were 7 to 90 and 2 to 28 respectively. These results corroborate our earlier findings. We have now covered most important soils in the country, and can conclude that at least 50—60% of our soils are deficient in phosphorus and need phosphorus fertilization to increase crop yield.

(b) *Placement studies on phosphorus for wheat and rice, pot and small; plot experiments with tagged material :* In paddy on the calcareous soil of Pusa (Botanical Sub-station) the general yield response to phosphate application was low. However, as reported in the previous year, the maximum utilization of added superphosphate by the crop was observed when the fertilizer was applied by broadcast followed by usual mixing. Placement of fertilizer at lower depths (2″—4″) resulted in lower uptake of phosphorus.

In wheat grown on Top Block I. A. R. I. Farm, Delhi, the yield response to phosphate was significant and placement of superphosphate at 2 or 4″ depths resulted in better utilization of the fertilizer (placement at 2″—20%, broadcast and mixed 14%).

(c) *Fixation, exchange and movement of tagged phosphorus in soils :* With a view to studying differential fixation of phosphorus on soils various probable extracting agents *e.g.* sodium acetate-acetic acid, 0·5M $NaHCO_3$, disodium salt of ethylene diamine tetracetic acid and acetic acid with 8 hydroxyquinoline were tried to differentiate between calcium phosphate and iron and aluminium phosphate systems. None of these were found to distinguish clearly between the two systems. Trials with reagents like sulphosalicylic acid and EDTA, which form complexes with iron and aluminium and calcium respectively were given to block particular groups from taking part in phosphorus fixation. Considerable decrease in fixation in laterites by sulphosalicylic acid and in calcareous soils by Versene (EDTA) was observed. However, the decrease in fixation could not be correlated with the contents of free sesquioxides or free $CaCO_3$ in these soils. Further work is in progress. The slopes of phosphorus uptake and utilization of applied phosphorus curves for soils used in our pot culture work and in the above study were calculated. It was found that tan θ values correlate significantly with percentage fertilizer utilization. For wheat 1956, for 10 soils, correlation co-efficients of +0·88 and for another 8 soils +0·98 and for paddy for 18 soils +0·945 were obtained.

Bulk amounts of two soils have been saturated to various degrees of phosphorus saturation to study uptake of phosphorus as influenced by percentage anion unsaturation.

54. *Correlation of several soil phosphorus tests with wheat and paddy crop responses :*

Available phosphorus was estimated by the carbon dioxide method in all the soils (seventy-nine in number) used in our potculture experiments on wheat and paddy. The results correlated poorly with the percentage yield response.

Further work on the development of a new method for determination of available phosphorus in soils in which versene and fluoride were used and reported last year was undertaken. Effect of fluoride ion, concentration of versene pH, soil : solution ratio and period of shaking on extractable soil phosphorus and its correlation co-efficients with percentage yield response were determined. The final proposed method uses 2·5 g. soil in 100 cc. of 0·1% versene solution containing 0·03 MNaF shaken for one and a half hour. It was found that the values of the correlation co-efficient are highly significant in all the green-house paddy and wheat experiments conducted by us and they are slightly superior to those for the Olsen method. The prediction value of the versene-fluoride method comes out to 70·7 and 62·1 for wheat and paddy respectively. The relationship between soil test values and % yield response is $Y = 120·37 - 46·27 \log x$ for wheat and $Y = 118·06 - 47·99 \log x$ for paddy. Based on results obtained, the level of versene-fluoride soluble phosphorus is as follows : < 30 lbs. P_2O_5 per acre a probable response, 30—80 lbs. P_2O_5 per acre a probable response and >80 lbs. P_2O_5 per acre response.

55. *Comparative efficiency of different phosphatic fertilizers through radiotracer studies for wheat and rice on major Indian soils :*

Tagged superphosphate, mono and dicalcium phosphates, calcium metaphosphates, mono and diammonium phosphates and ammoniated superphosphate were tried in a comparison on green-house wheat and paddy.

In paddy : for the alluvial soil the percentage fertilizer uptake varied from 14 to 63·5 and percentage fertilizer utilization from 2·6 to 12·87. Highest figures are in the case of calcium metaphosphate. For black cotton soil the same varied from 47 to 73 and 0·7 to 3·3; highest figures were for monocalcium phosphate and calcium metaphosphate. For calcareous soil the same varied from 24·7 to 98 and 4·0 to 20; highest figures were for mono and dicalcium phosphates. For laterite soil the figures were 14·9 to 38 and 3·3 to 17·2; highest figures are in the case of mono and diammonium phosphates. For wheat the results are under process.

56. *Availability of phosphorus in soils; effect of organic matter, EDTA, Na_2SiO_3 and moisture levels:*

The pot culture and laboratory data both showed that combined treatments of organic matter, EDTA and Na_2SiO_3 increased both the available phosphorus as well as the fixation capacity.

In another experiment it was found that different moisture levels did not have any effect on either available phosphorus, pH or phosphorus uptake.

F(c) Cartography

57. *Basic soil regions of India :*

In continuation of the work on the basic soil regions of India for applying the results of research obtained at one place to other similar areas, a study of slope conditions was computed for area bounded by 78° to 84° East and 16° to 28° North on the basis of 1·2, 2·4, 3·6, 4·8, 6·0 and 7·2% slopes.

58. *Soil Symbolization :*

Representation of vegetation on soil maps was carried out on a scale of 1″= 1·25 miles.

F(d) All-India Soil Survey Scheme

Soil survey and soil correlation work were undertaken by the Soil Correlators appointed for (i) Alluvial Soil Region at Delhi, (ii) Black Soil Region at Poona, (iii) Laterite Soil Region at Kharagpur, and (iv) Red Soil Region at Bangalore.

(i) *Alluvial Soil Region :* The soil survey of about 102,900 acres in Nawanshahr N. E. S. Block, Distt. Jullundar, Punjab and of 1,28,000 acres in Sohowal N. E. S. Block, Distt. Satna, Madhya Pradesh, were carried out. In Nawanshahr, three types of soils were distinguished :

Type A.—A sandy soil of uniform profile features with no lime and pH round about 8·0;

Type B.—Loamy soils with a distinct heavy B horizon ;

Type C.—Miscellaneous soils of low-lying areas ; it occurs near about the old river bank with a hard impermeable layer locally known as *Pandu.*

In Madhya Pradesh three major types were distinguished with two minor types : *Type A*—a dark grey brown deep clayey soil, with kankars in the profile; *Type B*—(i) a grey brown changing to olive brown with shallow clayey soil with no lime, (ii) Reddish brown, very sandy shallow soil with no lime ; *Type C*—a light yellowish brown to olive brown clay loam.

In the waste land of the area sink holes were observed as a net work locally known as Kurai which are similar to 'Gilgai soils' of Australia.

(ii) *Black Soil Region :* Reconnaissance soil survey and soil mapping of the Nasik District were carried out. The district was divided into the following regions :—

(*a*) Hilly area with high rainfall.

(*b*) Rolling to gently undulating topography.

(*c*) Rolling to plain land.

Useful data on crops and agriculture, irrigation, climate and rainfall of the District were also collected.

(iii) *Laterite soil Region :* The soil survey of an area of 110 sq. miles in the Asansol subdivision of the District of Burdwan, W. Bengal, was made. 15 soil profiles was examined and their micromonoliths collected.

(iv) *Red soil Region :* The survey of the soils of Coorg which was begun during the previous year, was continued, by detailed traverse and mapping. A large number of profile pits were dug and from a study of profile characteristics, eight soil series which represent major land areas and three soil series of minor importance were described and named. Over a dozen monoliths were collected for purposes of observation and reference. The area covered by this survey was over 60,000 acres. The survey of the soils of Andhra Pradesh commenced with Vayalpad Taluk in Chittoor district. About 5,000 acres were traversed in this area.

Programme of work for 1957-58

A. Agricultural Chemistry :

(a) *Soil Fertility :*

1. Fertilizer response in respect to yield of crop and uptake of nutrients.

2. Effect of dipping roots of paddy seedlings in fertilizer solution before transplanting, on growth and yield of paddy.

3. Effect of soaking seed of wheat and maize in fertilizer solutions on growth and yield.

4. Comparative study of the indicator plant method, Mitscherlich method and Neubaur's method for finding out the major nutrient deficiencies in black soils.

5. Effect of continuous use of organic manure (FYM) and inorganic fertilizers and their combinations on the quality of wheat.

6. Development of an economic plant and process for production of fuel gas and manure by anaerobic fermentation of Cow dung and organic-wastes suitable for extensive adoption on the villages.

(*b*) *Microbiology :*

7. Activation of azotobacter with and without cellulose decomposing organisms.

8. Studies on Rhizobium of wild leguminous plants.

9. Microbiological decomposition of herbicides (M.C.P.A.).

10. Ecology of Beijerinckia in Indian soils.

11. Effect of gypsum on the decomposition of organic matter and nitrogen transformations in soils.

12. Effect of cations & anions on the rate of nitrogen fixation by azotobacter.

13. Role of soil reaction on the availability of plant nutrients in soils.

B. Soil Survey & Soil Physics :

1. Genesis, standardisation of taxonomic units and nomenclature of Indian soils.
2. Mineralogical studies of parent materials.
3. Survey and mapping of Delhi State soils.

4 Studies on saline and alkaline soils and well waters.

5. Studies on soil structure.

6. Soil—moisture studies.

7. Scheme for the collection and collation of the soil survey data in India (ICAR).

8. Study of the properties and formation of black soils as affected by parent rocks.

9. Studies on laterites and related soil of the West Coast.

C. Physical Chemistry :

1. Studies on the ionic exchanges in soils, clays and clay minerals and plant roots.

2. Electro-kinetic properties of aluminosilicate precipitates, clay minerals and soils in relation to formation of clay minerals.

3. Mineralogical studies of soils & clays.

4. Studies on the separation and properties of clays and clay-humus complexes from soils.

5. Studies with interaction of clays and clay minerals and their significance on the determination of the mineralogical composition of clay.

D. Plant Chemistry :

(a) *Organic Chemistry :*

1. Preparation of synthetic pesticides.

2. Preparation of insecticides from natural sources.

3. Biogenesis of fats in plants during the ripening of linseed and mustard seed.

4. Carbon & Nitrogen status of soils in relation to soil fertility.

5. Development of antioxidants for edible oils and fats.

6. Co-ordinated scheme for the improvement of essential oils.

7. Synergists & insecticidal formulations based on indigenous materials.

(b) *Biochemistry :*

8. Nutritive value of crops as affected by manurial, cultural & storage factors.

9. Studies on plant enzymes.

10. Nitrogen metabolism in the plant and soil.

11. Biological function of micro-nutrients and their effect on the growth of food crops.

12. Biological value & amino acid make up of plant and animal proteins.

13. ICAR scheme on the foliar application of nutrients to crops.

E. Physics :

1. Spectrographic methods of analysis of soils & plants.

2. Study of the micro-element status of Indian soils.

3. Studies on the micro-element uptake of plants in relation to the nutritive value of grasses, forages etc.

4. Co-ordinated scheme for the investigation of micro-nutrients.

5. Study of the physical properties of purified preparations of plant viruses.

6. Qualitative and quantitative analysis of clay minerals by X-ray diffraction technique.

7. Estimation of micro-element by condensed spark and anode excitation method

8. Electron microscopic studies of clay minerals and viruses.

F(a) Soil Testing Service :

1. Determination of available nitrogen and correlation with crop responses.

2. Estimation of available phosphorus by different methods and correlation with crop responses.

3. Determination of available potassium by different extractants and correlation with paddy crop responses.

4. Soil Test Summaries and assessment of fertility status of Community Project Area and Delhi State.

F(b) Radio-tracer Investigations :

1. Available phosphorus in soils & phosphorus fertilizer utilization by rice, wheat, oats—a green-house-*cum*-laboratory study with Radioactive superphosphate.

2. Measurement of surface phosphorus of soils—isotopic exchange with radioactive phosphorus.

3. Placement studies in phosphorus for wheat and rice—pot and small plot experiments with tagged material.

4. Fixation, exchange and movement of tagged phosphorus in soils.

5. Comparative efficiency of different phosphatic fertilizers through radiotracer studies with wheat and rice on major Indian soils.

6. Phosphorus status of major Indian soils—effect of flooding, organic matter, cations, silicates.

F(c) Cartography :

1. Preparation of basic soil region Maps.

2. Compilation and preparation of maps from soil survey data and soil test summaries.

3. Standardisation of symbols for the compilation of soil map.

F(d) All-India Soil Survey Scheme :

1. Soil classification and nomenclature of—
   (a) Alluvial soils,
   (b) Black soils,
   (c) Laterite soils,
   (d) Red soils.

2. Soil and land utilization surveys in limited areas.

3. Correlation of Agronomic experiments conducted on an All-India basis with different soils.

REPORT OF THE DIVISION OF ENTOMOLOGY

(Dr. E. S. Narayanan)

General

(a) *National Pusa Collection* : Ninety-one specimens of insect species, so far totally unrepresented or very poorly represented, were added to the National Pusa Collection. In addition, a thousand other insect specimens have been locally collected and two hundred and fifty others procured from Sikkim and added to the collection pending identification. The rearrangement of the main collection, according to the most recent taxonomical trends, has been taken up ; the work, in this connection, on the Ichneumonidae has made considerable progress.

One hundred and fifty-nine named insect specimens were supplied to different institutions in the country. Besides this, specimens of the adults of various sugarcane borers, along with the literature on them were supplied to the Chinese Government. Three different species of Indian honey bees, together with sample pieces of their combs, were supplied to the Czechoslovakian Government through their embassy in New Delhi.

(b) *Delhi Intensive Cultivation Scheme* : The staff of the Division continued to survey the crop pests and demonstrate control operations against major insect and other animal pests of agricultural crops. Control measures were undertaken against cutworms on gram (9 acres), Singhara beetle on water-nut (7 acres), Gundhi bug on paddy (1 acre), borers in sugarcane and juar (1 acre), red pumpkin beetle on cucurbits (22 acres), fruit pests (280 fruit trees) and rats (300 acres). Demonstrations of spraying and dusting machines and lectures on pest control were arranged in Budhela and Nangloi villages on the occasion of 'Kisan Melas'.

Research Projcets

Systematic Entomology:

Taxonomic research work was continued on the Indian Curculionidae and Coccinellidae (Coleoptera), Vespidae, Ichneumonidae and Chalcididae (Hymenoptera) and Aeshnidae (Odonata) and studies on Aphidiae and Membracidae (Homoptera) and Encyrtidae (Hymenoptera) were taken up. Widely scattered literature on these groups were being collected in an attempt to bring these together in the form of Monographic works on the same lines as the series of the "Fauna of British India" or the "Catalogue of Indian Insects". Insect collections specially made for these studies have brought to light several forms quite new or so far unrecorded in our country. These include different species falling under the genera *Stomatocerus*, *Antrocephalus*, *Hockeria*, *Euchalcidia*, *Dirrhinus* and *Hontalia* under the Chalcididae ; *Cerapterocera* and *Tetralophidea* under the Encyrtidae; four different species of Lachninae (Aphididae) and a species of *Cocostrephus* (Membracidae). Further critical studies on these have progressed. As a result of careful studies on the genitalia of different species of Vespidae, it has been found that these armatures confirm the separation of the genera *Rhopalidia*, *Polistes* and *Vespa* under three distinct sub-families, *viz.* Rhopalidinae, Polistinae and Vespinae ; the aedeagi particularly and the parameral spines to some extent being quite characteristic for each of these taxons. Further, the male genitalia of *Rhopalidia* showed a gradation of characters from those of the Eumeninae thus indicating a definite phylogenetic affinity with this sub-family.

In the Coccinellidae, comparative studies on the terminalia of two sub-families, the Epilachninae and the Coccinellinae, showed that the former cannot be recognised as anything more than a tribe of the latter sub-family. The gradational series of variations in the species of *Stethorus* justified its separation from the Scymnini. The variations noted in the various Indian representatives of the entire family indicated a definite evolutionary trend on the basis of which a phylogenetic tree for the various taxonomic groups has been drawn up.

Insect Parasitology

Fundamental Studies :

1. *Effect of nutrition on the longevity, fecundity and sex-ratio of Bracon gelechiae Ashmead and Trichogramma evanescens minutum Riley using Corcyra cephalonica Staint as their host fed on various synthetic diets :*

(a) *Effect of food on the growth of Corcyra larvae* : The growth of *Corcyra* larvae was studied on the following diets : (i) crushed juar (control), (ii) fat free crushed juar, (iii) juar flour passed through 100 mesh seive, (iv) crushed juar mixed with fat free groundnut in 9 : 1 ratio, (v) crushed juar with ether extract of groundnut in 9 : 1 ratio, (vi) crushed juar mixed with groundnut in 4 : 1 and 2 : 3 ratios, (vii) crushed groundnut, (viii) wheat flour and (ix) wheat flour mixed with yeast in 19 : 1and 9 : 1 ratios.

Observations showed that the growth of *Corcyra* larvae was significantly better when fed with crushed juar mixed with groundnut in 4 : 1 ratio as compared to the rest of the diets.

(b) *Effect of larval food on the parasite Bracon gelechiae* : The host larvae (*Corcyra*) were fed with crushed juar singly and in combination with casein, groundnut and nicotinic acid in different proportions and these were later on utilised for the rearing of the adult parasites. It was observed that adults reared on the host fed with crushed juar mixed with nicotinic acid at the rate of 10-20 micro grams per gram of juar gave the best results so far as the longevity, fecundity and sex-ratio of the parasite was concerned. It was further observed that the parasite fared well at least up to 20 micro grams of nicotinic acid per gram of juar from the point of view of longevity, fecundity and sex-ratio.

2. *Studies on the Chalcid egg parasites of Pyrilla perpusilla Walk :*

(a) *Fecundity of Ageniaspis pyrillae Mani* : Observations on the fecundity of the parasite reared at temperatures of 25°C, 18°C. and 10°C. and under one relative humidity of 80% did not show any significant increase when fed with sucrose, glucose and fructose solutions as compared to no sugar. Temperature, on the other hand, had a marked effect on fecundity and no egg laying was observed at 25°C. and 80% relative humidity. At 18°C. and 80% relative humidity the fecundity was the maximum.

(b) *Embryology of Tetrastichus pyrillae Crawford* : Microtomic studies showed that the duration of the blastula stage was 11 hours and that the germ layer formation began after 23 hours. The nervous system appeared as soon as the germ band got differentiated into germ layers.

(c) *The effect of low temperature (refrigeration) on the viability of the eggs of Tetrastichus pyrillae* :. Observations showed that 6 days, 9 days and 10 days exposure of the parasite pupae to 10°C. and 80% relative humidity gave 85·42%, 68% and 59·08% average adult emergence respectively when these were transferred to 25°C. and 80% relative humidity after the exposure period. Host larvae exposed to similar conditions showed no emergence of adults for 9 and 10 days exposure periods while 92·3% adults emerged with 6 days exposure period.

(d) *Superparasitism in Tetrastichus pyrillae* : 40 *Pyrilla* eggs were exposed to a single mated female parasite for two hours and only 10% of the host eggs were parasitised with no case of superparasitism. The exposure period was gradually increased to 24 hours with an identical fall in the number of host eggs exposed to 5 only. Superparasitism was not found to occur under these conditions of experimentation.

(e) *Factors affecting the ratio of reproduction of Bracon brevicornis Wesmeal* : Studies have been made on the effects of physical and biological factors on the rate of reproduction of this parasite. Physical factors studied were temperature, humidity and light while biological factors included density of host and parasite, nutrition and size of host and restraint on oviposition. Observations have shown that temperature and nutrition are the only twin factors that predominantly govern the rate of reproduction in this parasite.

3. *Mass breeding of parasites :*

About 220,000 *Corcyra* moths were reared and about 550 cc. of eggs were laid by these moths. The eggs were used for mass production of *Trichogramma* and other parasites as well as for maintaining the *Corcyra* culture. A little over 25 lakh of *Trichogramma* parasites were reared. The cultures of *Bracon gelechiae*, *B. brevicornis*, *B. hebetor*, *Apanteles angaleti* and *Glyptomorpha deesae* were maintained.

Insect Ecology and Toxicology

1. *Studies on the development and distribution of insects under different ecological conditions.* :

(a) For testing the efficiency of the biometer constructed for the chalcid parasite *Trichogramma*, the rate of development of the parasite under constant and fluctuating temperatures was determined during different seasons. Studies on the tolerance of the eggs of the parasite to 37°C., 39°C , 41°C., 43°C. and 45°C. under 75% relative humidity showed that development did not take place when the parasitised eggs were exposed for 20, 10, 8, 6 and 2 hours respectively to these different temperatures.

(b) The development of *Chilo zonellus*, a very important pest of maize and jowar, was studied at constant and alternating temperatures ranging from 10°C. to 35°C. Studies were also carried out on the effect of exposure of different stages of the pest to the extremes of temperature and humidity. Observations on the larvae overwintering in the field showed that they overwinter in different physiological states ; some appear to be in a state of diapause while others respond to an exposure to suitable temperature.

(c) Studies on the effect of density upon the fecundity of *Callosobruchus chinensis* have shown that oviposition area remaining constant, the fecundity of this stored grain pest significantly falls with rise in density of the beetles per grain. In an unconditioned medium fecundity also falls significantly with the reduction in the oviposition area.

2. *Studies on population determination and assessment of damage :*

Bioclimatic fluctuation in the population of *Bagrada cruciferarum* was continuously recorded. Two generations of the pest were successfully reared on soaked mustard seeds. Further studies on longevity and fecundity of the pest were continued.

3. *Effect of chemical control on the biological balance in cultivated crops :*

(a) *Control schedule for mustard crop* : The experiment was repeated for the third year. This year the aphid infestation was both late and mild necessitating only two sprayings with the various insecticides during the season. Observations showed that on the basis of the average yield from the different treatments, the relative efficacy of the various insecticides was in the order parathion>*gamma*BHC>pestox>basudin>dieldrin>nicotinesulphate.

(b) *Effect of DDT sprays on the balance of pest population in the cotton crop* : The experiment was repeated for the second year and sprayings with DDT suspension at the rate of 1 lb. per acre was done as last year. Observations after the 5th spraying showed that the population of jassids, thrips, white-flies and aphids was reduced by 100%, 96·2%, 92·6% and 70·8% respectively whereas that of pink bollworm and mite increased by 66·6% and 40·75% respectively.

4. *Exploration of factors determining the susceptibility of insects to insecticides :*

Studies on insect cuticle in relation to susceptibility to insecticides : The relative solubility of DDT, BHC, dieldrin and endrin crystal suspensions in the films of cuticular wax of *Tribolium castaneum* was studied and this was found to be positively correlated with the relative toxicity of these insecticides to this pest.

5. *Bioassay of insecticides.*

(i) Studies on the efficacy of pestox 3 and systox as systemic insecticides against *Rhopalosiphum pseudobrassicae* showed the latter to be more toxic than the former. The experiments were conducted in potted plants and the insecticides were used in irrigation water. Similarly systox proved to be more toxic than pestox-3 against *Bagrada cruciferarum.*

(ii) Observation made on the fumigation of *Tribolium castaneum* in wheat kept in bins showed that carbon tetrachloride was more effective than either EDCT mixture or ethylene dichloride. In bulk fumigation of about 35 maunds of wheat, carbon tetrachloride used at the rate of 8 lbs. per 1000 cu. ft. with 24 hours exposure period ensured complete mortality of *Tribolium castaneum* and *Rhyzopertha dominica.*

(iii) *Toxicological and ecological studies on locust* : (a) Preliminary studies were carried out on the toxicity of insecticides injected into the body cavity of 2nd to 4th stage hoppers of the desert locust, *Schistocerca gregaria.* The following order of toxicity was found for all the stages aldrin >dieldrin>chlordane>parathion>endrin >diazinone >isodrin>systox> lindane> HETP>malathion>toxaphene>nicotine sulphate>DDT>pestox.

(b) Studies on the relative toxicity of four modern insecticides used as stomach poisons against different stages of the desert locust, *Schistocerca gregaria*, showed a sudden increase in resistance in the adult stage as compared to the hopper stages. The toxicity of the different insecticides was found to be of the order : dieldrin >aldrin >lindane >endrin.

(c) Studies on the oviposition response of locusts in sand varying in moisture content from 2 to 8% showed the bulk of egg laying at spots showing 6 to 7% moisture content.

(iv) *Effect of contact insecticides and fumigants on the infestation and viability of stored grains* : Experiments carried out at Pusa (Bihar) showed that there was as much as 60% infestation in untreated maize yellow-2 stored as control from December 1955 to August 1956 whereas the infestation ranged only between 0·5 to 6% in the various dust treatments. Treatment with 10% DDT dust used at the rate of 4 oz./125 lbs. gave the best results. Viability of the treated seeds ranged between 26·1% to 61·7% as against only 16·3% in the control. Similar studies were also carried out on wheat NP718 treated differently and stored for little over one season at Pusa (Bihar) and I.A.R.I. (Delhi).

Experiments on the effect of higher dosage of chlorosol and longer exposure periods on the viability of wheat NP718, barely NP13, gram NP58 and peas NP29 showed that the viability was not impaired when the fumigant was used at the rate of (a) 100 lbs./1000 mds. with an exposure period of 72 hours and (b) 40lbs./1000 mds. with exposure period of 7 days. Also the seeds showed no impairment of viability even when they were fumigated repeatedly for 10 times at fortnightly intervals at the rate of 40 lbs./1000 mds. with 24 hours exposure period. Also the viability was not impaired when these seeds were treated with 15% DDT, 0·5% *gamma* BHC and dieldrin and 0·2% pyrethrin dusts used at the rate of 8 oz. per 125 lbs. of grain and stored at Delhi from August 1956 to March 1957. No impairment of the viability of the wheat seeds was observed when the same was fumigated with carbon tetrachloride and carbon disulphide used at the rate of 60 and 40 lbs. per 1000 cu. ft. space respectively with 24 hours exposure.

(v) *Field and laboratory tests with Pyrethrum used against important crop and stored grain pests* : 0.125% and 0·25% pyrethrin emulsions with kerosone oil or petroleum ether as bases and with or without 1% pine oil or 1% and 2% piperonyl butoxide as synergists were sprayed against grubs of *Trogoderma.* The experiments were conducted at laboratory temperature and at controlled temperatures of 25°C., 30°C., 33°C. and 37°C. Pyrethrin emulsions with piperonyl butoxide were found to be more toxic than pyrethrin alone while there was no significant increase in mortality in the case of pyrethrin in combination with pine oil.

(vi) *Control of fly breeding in compost pits :* The experiments were again repeated with a slight modification in the technique : instead of one application at the surface the dusts were applied in three layers, one at the top and the other two at two and three inches below the top surface. Observations based on the number of flies amergd from each treatment showed the following tentative order of efficacy : 0.5% aldrin> 0.13% *gamma* BHC>0.5% endrin >0.5% malathion>control.

(vii) *Plant Introduction* : Preliminary tests were in progress on the treatment of Pappaya sapplings with double the recommended dose of DDT, dieldrin, malathion and lindane emulsions. The last two insecticides caused slight burning of the leaf-tips. Similar tests were in progress with HCN fumigation.

Trials with the various fumigants against *Gnorimoschema operculella* in potatoes showed the following order of toxicity : acrylon>carbon disulphide=methyl bromide>carbon disulphide +carbon tetrachloride>carbon tetrachloride used at higher concentrations than recommended. These fumigants showed no adverse effects. Similar studies were also in progress with these fumigants against adults of *Drosicha mangiferae* (Green).

Schemes

(A) Second Five Year Plan :

I. *Entomological investigations with the help of radio active isotopes :*

(i) *Effect of the radio activity on the rate of reproduction, development and longevity in Microbracon gelechiae Ashmd.*: Preliminary experiments carried out by feeding the host larvae on radio active maize and later giving them for parasitisation showed that with lower levels of radio activity there was a tendency on the part of the parastite to lay more eggs as compared to control.

(ii) *Studies on Pestox III labelled with P* ^{32} : Studies showed that radio active pestox III is readily absorbed by the roots of cotton seedlings and later translocated to stem and leaves, the increase in activity in the leaves continuing up to the 5th day. Adults of the red cotton bug, *Dysdercus koenigi* K. were found to pick up pestox III from the insecticidal film although this insecticide is considered to be predominently a systemic insecticide.

(iii) *Physiological investigations with P* ^{32} : Studies on the tolerance to β-radiation by adult locust showed that a dose of 3000 μc had no adverse effect on the longevity of the insect. Similarly a dose of 50 μc had no adverse effect on the viability of the eggs of *Tribolium castaneum* when exposed for a maximum period of 144 hours.

II. *Biological testing and certification of insecticides :*

Nine commercial samples of 5% BHC, 1% aldrin, 5% and 10% DDT and 1% dieldrin dusts and fish oil rosin soap were tested for their toxicity and compared with the laboratory-made formulations of these insecticides. Similar tests were also made with endrin, aldrin and malathion obtained in the form of emulsifiable concentrates from various firms.

Also seven chemicals received from the Division of Chemistry were tested for their toxicity. These chemicals were found to be much less toxic when compared to DDT and *gamma* BHC.

Studies on the various insecticides when used as a spray emulsion showed the following order of toxicity against larvae of *Euproctis lunata*: endrin>isodrin>diazinone>dieldrin>aldrin *gamma* BHC>DDT>toxaphene>malathion>chlordane. When used as films, endrin, diazinone and dieldrin were also found to be more toxic than DDT and malathion and gamma BHC were inferior to DDT. Against the mustard aphid, *Lipaphis erysimi*, the order of toxicity of fifteen insecticides tried was as follows : parathion>systox>malathion>diazinone>gamma BHC> endrin >HETP >pestox >isodrin >nicotine sulphate >dieldrin >aldrin >chlordane > DDT >toxaphene.

III. *Ecological studies on Stored grain pests :*

The utility and practicability of removing moisture from the grain stored in pits at periodic intervals without opening the pits were under exploration and some preliminary experiments carried out showed that it appears to be quite a promising line to follow up.

Studies on the development of the different stages of *Trogoderma* sp. and *Sitotroga* sp. were continued under different ecological conditions. Observations on the incubation period of eggs, pupal period and longevity of adults of the former at [illegible], 25°C., 30°C. and 35°C. and relative humidities of 45%, 60%, 75% and 90% were completed. Studies on *Sitotroga* were carried out at 30°C. and 35°C.

Ecological problems of storing paddy and rice in some parts of Bengal and those of wheat in Delhi villages were studied.

IV. *Seed testing :*

1,585 samples of seeds of various commodities were examined, treated where necessary, and health certificates issued. A survey was started to make a list of all insects pests of vegetable seeds. Experiments were in progress to study the effect of various insecticides on the viability of vegetable seeds. So far EDCT mixture used at eight times the recommended dose was not found to have any detrimental effect on the viability of some cucurbit seeds.

V. *Indian Honey Bee* :

At the Botanical Sub-station, Pusa, 12 colonies of *Apis indica* were established for starting research work in connection with the raising of pedigree queens by supersedeary impulse. Observations were being taken every day on the activities of the bees of these 12 hives with a view to select the best colony for the breeding of the drones and the next best colony for the breeding of the virgin queens.

VI. *Insect Physiology* :

(1) *Morphology and physiology of the insect egg-shell and penetration of chemicals through it :*

Out of the many chemicals tested, nickel chloride was found to be quite effective as an ovicide against *M. gelechiae*, *Dacus* sp. and *Corcyra cephalonica* parasitised by *Trichogramma evanescens minutum*. The chemical is, however, effective only if the eggs are pretreated with an alkali.

Further studies on the eggs of *M. gelechiae*, *C. cephalonica*, *Chilo zonellus* and *Pyrilla perpusilla* have indicated that the penetration of aqueous and lipophillic chemicals is not obstructed by chorion and cement, but the latter often retains some poison to kill the larvae eating their way through. The entry of aqueous poisons is chiefly obstructed by the lipoid layer and even by the epembryonic membrane containing oily material. This oily material is absent from the egg shell and epembrynoic membrane of the endo-parasitic eggs.

(2) *Plant breeding for resistance to insect pests (in collaboration with Botany Division) :*

Effect of nutrients and micronutrients on the metabolism of insect pests of major crops : Artificial diets of known composition have been compounded for *Chilo zonellus*, *Earias* sp. and *Gnorimoschema operculella*. The larvae of the first two insects could be successfully raised on these diets upto adult stage. This is first record that these insects have been reared on synthetic diets.

(3) *Nutrition of insects associated with stored plant products :*

Nutritional studies were made on *Oryzaephilus surinamensis*, *Tribolium castaneum* and *Trogoderma granaria*. Effect of various nutrient factors on the insects was investigated.

(4) *Rearing of beneficial insects including parasites in artificially compounded and semi-natural diets :*

Microbracon gelechiae, which is an ectoparasite on Lepidopterous larvae, was reared from larval stage to adult stage outside the host, on an artificial liquid diet. Further work is in progress to improve upon the food and technique of rearing so as to minimize high rate of mortality among the larvae.

(5) *Symbiosis and its physiological significance. :*

High temperature of 36°C. failed to bring about complete eradication of micro-organisms in two beetles : *Oryzaephilus surinamensis* and *Rhizopertha dominica*. However, the eggs of *O. surinamensis* could be made aposymbiotic if treated with ultraviolet rays of 2573°A wave length.

Caecal bacteria of 5 different species of Coreid bugs have been isolated and cultivated on artificial media.

(6) *Investigations on the digestive physiology of insects :*

Only midgut of *Chilo zonellus* larvae secretes amylase, maltase, invertase, lactase, lipase and tryptic type enzyme. No other part of the alimentary canal secretes enzymes. The salivery glands secretes only amylase. The pH of different parts of the alimentary canal and its associated parts has also been determined.

(7) *Physiological studies on fruit flies with special reference to nutritional requirements :*

Mycetomes have been located in the larvae of *Dacus* sp. and bacteria have been found to be present in them. This insect has been reared up to adult stage on carrot medium.

VII. *Survey of beneficial parasites and predators of pests of agricultural crops in the Indian Union. :*

An extensive survey was undertaken in Madras, Andhra, Mysore and Kerala States and collections of parasites and predators were made. 25 species of parasites were recorded of which 20 were new to science. The genera *Dusmetia, Ectromatopsia Chrysopophagus, Anabrolepis, Thysanus, Asaphes, Microterys, Trioxys* and *Scotolyns* have been recorded for the first time from the Indian Union. The parasite complex of *Hymenia recurvalis* was investigated and it was interesting to note that the primary parasite *Apanteles delhiensis* new sp. was hyperparasitised by at least 8 species of secondary parasites.

A list of parasites of agricultural crop pests of the Indian Union comprising 50 species that are not referred to in the catalogue of parasites issued by the Commonwealth Institute of Entomology was prepared and sent to all the State Entomologists and the Director, Commonwealth Institute of Biological Control, Ottawa, Canada. The list was acknowledged by the Director of the Commonwealth Institute of Biological Control who said that the list that we sent was useful.

(B) I. C. A. R. Schemes :

(1) *Biology and control of termites affecting agricultural crops :*

Experiments were in progress on the control of termites in sugarcane and wheat fields by treating the soil with various organic insecticides. In sugarcane 1% DDT used at the rate 16 lbs. per acre gave the best results from the point of view of yield. Studies on varietal resistance in wheat showed that there was not much difference among the eight varieties tried from the point of view of both infestation and yield.

Attempts were made to study the biology of a species of termites by liberating a pair each in dishes for breeding purposes. Egg laying was observed and the nymphs that hatched out in about 3 weeks time lived for about 6 weeks after which they died. The colonies survived for about two and a half months.

(2) *Exploration of toxicity hazards in the use of modern insecticides against cattle and human beings :*

Experiments were planned and only some preliminary observations were made on the decomposition of DDT dust mixed in wheat and the residue of DDT and BHC on vegetables and fruits.

Programme of work for 1957-58

A. Section of Parasitology :

A_1—Effect of nutrition on the fecundity, longevity and sex-ratio of *Bracon gelechiae* Ashmead and *Trichogramma evanescens minutum* Riley reared on *Corcyra cephalonica* St. fed on various synthetic diets.

A_2—Host selection and distribution of progeny in *Microbracon chinensis* Szep. and *M. brevicornis* Wesm.

A_3—Studies on coefficient of parasite efficiency of some parasites of cotton boll worm and the root, stem and top borers of sugarcane.

A_4—Biological control of pink boll worm, *Pectinophora gossypiella* (Saunders), by means of its parasites *Apanteles angaleti* Muesebeck and *Microbracon brevicornis* Wesm.

A_5—Biological control of the potato tuber moth infesting potato in storage.

A_6—Studies on Chalcid egg parasites of *Pyrilla perpusilla* Walk.

A_7—*Schemes under the Second Five Year Plan* :

(i) Survey of beneficial parasites and predators of pests of crops in the Indian Union.

(ii) Effect of selective breeding on the longevity, fecundity and sex-ratio of *Trichogramma evanescens minutum* Riley.

B. Section of Insect Ecology and Toxicology :

B_1—Studies on the development and distribution of insects under different ecological conditions.

B_2—Studies on population determination and assessment of damage.

B_3—Effect of chemical control on the biological balance of cultivated crops.

B_4—Factors responsible for variation in the susceptibility of insects and the toxicity of insecticides.

B_5—Bioassay of insecticides.

B_6—Toxicological and ecological studies on the Desert Locust.

B_7—Studies on the effect of the contact insecticides (DDT, BHC, Dieldrin) and fumigants (CS_2, HCN and Chlorosol) on the insect infestation in stored grains and the viability of seeds.

B_8—Field and laboratory tests with pyrethrins against important crop and stored grain pests.

B_9—Laboratory tests on the chemical control of the Desert Locust in flight and situ.

B_{10}—Oviposition response by the Desert Locust.

B_{11}—Phenological observations on crop pests.

B_{12}—Plant Introduction.

B_{13}—I. C. A. R. Termite Research Scheme.

B_{14}—I. C. A. R. Scheme on toxicity hazards of modern organic insecticides to human beings and cattle.

B_{15}—*Schemes under the Second Five Year Plan* :

(i) Entomological investigations with radioactive isotopes.

(ii) Biological testing and certification of insecticides.

(iii) Ecological studies on the insect pests of stored grain.

(iv) Testing and certification of improved varieties of seeds.

(v) Bee-keeping.

C. Section of Systematic Entomology :

C_1—Taxonomy of Indian Curculionidae (Coleoptera).

C_2—Taxonomy of Indian Aeshnidae (Odonata).

C_3—Studies on Indian Ichneumonidae (Hymenoptera).

C_4—Review of the Chalcidiadae (Hymenoptera)

C_5—Taxonomy of Indian Tenebrionidae (Coleoptera).

C_6—Studies on *Lasioderma serricorne*.

C_7—Studies on Indian Encyrtidae.

C_8—Studies on Membracidae.

C_9—Studies on Aphididae.

D. Section of Insect Physiology (Scheme under the Second Five Year Plan) :

D_1—Plant Breeding for resistance to insect pests.

D_2—Nutrition of insect associated with stored plant products.

D_3—Rearing of beneficial insects including parasites in artificial diet.

D_4—Symbiosis and its physiological significance.

D_5—Digestive physiology of insects.

D_6—Physiological studies on fruit flies with reference to nutritional requirement.

REPORT OF THE DIVISION OF MYCOLOGY AND PLANT PATHOLOGY

(Dr. R. S. Vasudeva)

A. Section of Plant Pathology :

1. *Wheat (Triticum aestivum L.)* :

(a) *Rusts* [*Puccinia graminis tritici* (Pers.) Erikss. and Henn., P. *triticina* Erikss. and P. *glumarum* (Schmidt.) Erikss. and Henn.] : Four hundred and thirteen samples of black, brown and yellow rusts of wheat, collected from different parts of the country, were analysed for physiologic race study and races 15, 17, 21, 34, 40, 42 and 42-B of black rust, 10, 11, 20, 26, 63, 70, 77, 106, 107 and 108 of brown rust and 13, 19, 20, 31, A and G of yellow rust were obtained. Race 17 of black rust, hitherto unrecorded from India, was isolated from two samples collected from the 1954 crop of Lahaul valley, Punjab. Indications of a new race of brown rust, resembling race 162, were also obtained. Race 70 of brown rust reported from Punjab last year was met with again this year from the same State. Races 42-B, 21 and 40 of black rust, 20 and 63 of brown rust and 19 and A of yellow rust were predominant and widely distributed throughout the country whereas the virulent race 122 of black rust was not encountered for the second successive year.

Survey of the Upper Simla Hills showed that the wheat rusts could survive during summer months in various localities. Further evidence of over-summering of yellow rust on *Muehlenbergia hugelii* in Himachal Pradesh was obtained. None of the rusts, collected on 59 wild grasses from Simla and Nilgiri Hills, resembled any of the three rusts of wheat. However, natural infection of black and yellow rusts of wheat was observed on 4 species of *Agropyron* and 14 species of *Aegilops* in test plots at Simla. Besides the survey for naturally infected grasses, thirty-four grass species, belonging to 16 genera, were tested against the three rusts of wheat and black rust of oats. *Aegilops bicornis*, *A. triaristata.*, *A. ovata* and *A. squarrosa* were found susceptible to the three rusts of wheat, but immune to black rust of oats; *Phalaris canarensis* and *Avena glauca* were susceptible to black rust of oats only; and *Agropyron triticeum* showed susceptibility to black rust of oats and to black and yellow rusts of wheat. Finally, 186 seedlings of *Aegilops caudata* were tested with all the races and biotypes of the three rusts of wheat individually and the grass was found to be susceptible to some races of the three rusts and resistant to others.

Studies on alternate hosts were continued. *Aecia*, collected on *Berberis lycium* from Simla Hills and on *B. tinctoria* from Nilgiri Hills, did not infect wheat or *Agropyron* even though they showed 10-15% viability. Selfing studies with races 21 and 42 of black rust, which gave indications of heterozygosity of the races last year, were continued and the segregates so obtained on *Berberis lycium* were being studied. Crossing studies between *Puccinia graminis tritici* and *P. graminis agropyri* were also in progress.

In aerobiological studies, aeroscope slides from 15 rust nurseries exposed during 1955-56 and from 3 nurseries during 1956-57 were examined. From the 1955-56 lot, 5 cases of spore showers for black rust 3 for brown rust and 4 for yellow rust took place long before the recorded dates of rust appearance in the respective localities. From the second lot, however, spores of all the three rusts of wheat were caught at two nurseries and of black and brown rusts at one nursery at least a week before the reported dates of rust appearance.

In all 17, 654 plants of wheat varieties, their crosses and progenies were tested in the seedling stage either with individual races of the wheat rusts or their mixture. None of the varieties was found to be resistant to all the individual races of black and brown rusts. Variety P.D.14 was, however, resistant to all the races (except race 31) of yellow rust. In tests with mixtures of all the races of the three rusts of wheat separately, varieties E. 2842, E. 2845, E .3072, E .3099, E. 3123 and E. 3133 were found to be resistant to black rust; E. 781, E. 853, E. 855, E. 920, E. 942, E.946, E. 971, E. 981, E. 1013, E. 1912, E. 2143, E. 2144, E. 2547, E. 2548, E. 2562, E.2827, E. 2842, E.3070, E. 3099, K.A.D.E. 1108, Domes, Mentana, H.P.52-31 and five selections

of the cross W. 292 resistant to brown rust; and E. 876, E. 976, E. 2067, E. 2546, E. 2576, E. 2604, E. 2839, E. 2841, E. 3070, E. 3133, Domes and 60 cultures of different crosses resistant to yellow rust.

In adult resistance, tests, about 46,000 plants at Simla were examined for their resistance to the three rusts of wheat and 18,200 plants at Delhi for their resistance to yellow rust after creating artificial epidemic in field. Observations for the other two rusts at Delhi could not be completed due to severe hail storm in the month of March which damaged the wheat crop. The selection of promisng material was carried out jointly with the Wheat Breeder. Tests of the adult plants of Ridley variety revealed that it was susceptible to most of the races of black rust, though it had shown resistance to the same races in the seedling stage.

Detailed studies of black rust races (except races 42-B and 72) revealed some differences in the uredospore colour, pustule nature and incubation period. The incubation period was found to be different for different races at the same temperature. A combination of races 21 and 40 of black rust in equal proportions was maintained on *Agra local* wheat for five successive generations without any appreciable change in the frequency of the two components. There were, however, marked differences in frequency when the same mixture was put on some other varieties *e.g.*, C. 591, N.P. 4, N.P. 710 and N.P. 718.

(b) *Loose Smut* [*Ustilago tritici* (Pers.) Rostr.] : Out of 57 wheat varieties tested for their resistance to the disease under field conditions at Delhi, 35 remained free from infection. Amongst the smut-free varieties, E. 1913, H.D. (52)-46, H.D. (52)-67, H.D. (52)-70 and H.D. (52)-71 have remained free from smut infection during the last 3 years' tests. In some of the susceptible varieties infection as high as 81 to 100% was obtained. Effect of date of sowing on disease incidence seemed to depend upon the variety under test. Some varieties showed increased infection in the first sowing (6-11-56), others in the second sowing (24-11-56) and still others showed no appreciable difference. In the varietal resistance tests at Simla with 49 varieties, 36 remained free from infection, of which varieties N. P. 784,N.P. 792 and N.P. 810 have consistently remained free from infection during the last three years.

Work on the selection of resistant sub-strains within the highly susceptible variety N.P. 775, which otherwise shows desirable agronomic characters, was continued. The inoculated material of 286 single plant selections, which had remained smut free last year, was sown. Of these, 57 selections, showing less than 10% infection, were inoculated for further selection.

Hybridization of N. P. 775 with the resistant varieties N. P. 790 and N.P.798 for the selection of resistant plants was in progress in the Botany Division. B2 plants and promising material from F2, F3, and B1, selfed generations were inoculated. The infected material will be sown in the following season for assessing its reaction to the disease.

Further studies with eight isolates of *U. tritici* gave additional evidence of the occurrence of physiologic races within the pathogen.

Experiments on chemotherapeutic control of the disease showed that the pathogen could be eliminated from the infected seed (N. P. 775) by soaking it in copper-free distilled water at 25°C and 30°C for 41-48 hours and 23-29 hours, respectively. Soaking of the seed at 20°C for even 53 hours did not help in this connection.

(c) *Karnal Bunt* [*Neovossia indica* (Mitra) Mundkur] and *Hill Bunt* [*Tilletia caries* (D.C.) Tul. and *T. foetida* (Wallr.) Liro] : of the 95 wheat varieties inoculated for varietal resistance tests at Karnal under field conditions with the sporidial suspension of *Neovossia indica* both by the Hypodermic Syringe method in boot-leaf stage and by Moore's Partial vacuum method at mid-anthesis stage, 42 varieties remained free from bunt infection. Amongst the susceptible varieties, N. P. 165 and N. P. 720 showed as high as 86% and 80% infection, respectively, on ear basis. The maximum infection obtained in individual ears on grain basis was 92% in variety H. D. (53)-142. Infection was considerably higher when the ears were inoculated in boot-stage than in anthesis stage. Higher infection was also obtained when the inoculations (boot-stage) were made in early February than in late February.

Out of 61 wheat varieties under test against *T. foetida*, seven varieties, namely, E.192, E.197, E. 201, E. 2327, W.B. 941 (Hussar × Ridley) F1 and a foreign variety appeared to be resistant. In the case of varieties W.B. 94 and (Hussar × Ridley) F1, however, the number of plants under observation was rather small and, therefore, these tests require to be repeated. Of the six varieties (E. 56, E. 187, E. 192, E. 201, E. 740 and E. 2327) found resistant last year, three (E. 56, E. 187 and E. 740) showed susceptibility this year. Resistance of E. 56 and E. 740 has been correlated with the presence of adpressed glumes on the seed as the percentage of infection obtained in E. 56 and E. 740 when the seed was inoculated with glumes intact was 42 and 0.8 and without glumes was 86 and 82, respectively. Four samples of *T. foetida* and 1 of *T. caries* were analysed for physiologic race study, and the presence of 2 races in *T. foetida* and 1 race in *T. caries* was indicated. Bunt spores, when kept on the surface of soil or in the soil under wet conditions, lost their viability within 78 days. Mycelium of the fungus could be observed in the growing points of the infected wheat seedlings. Date of sowing and depth of sowing appeared to have considerable effect on the development of the disease.

(d) *Flag smut* (*Urocystis tritici* Koern.) : Due to low incidence of smut infection in the artificially inoculated plots, it was not possible to evaluate the results of varietal resistance trials. Natural incidence of the disease was also very low as can be judged from the fact that it was traces in N. P. 710 at Delhi and only slightly more in C. 13 at Karnal, whereas other varieties did not show any infection.

2. *Barley* (*Hordeum vulgare* L.) :

(a) *Rusts* [*Puccinia graminis tritici* (Pers.) Erikss. and Henn. *P. glumarum* (Schmidt.) Erikss. and Henn. and *P. hordei Otth.*] : Twenty-six samples of black and yellow rusts, collected from different parts of the country, were analysed and races 15 and 42-B of black rust and 19, 13 and G of yellow rust were met with. Nine barley varieties (654 seedlings) were tested against the individual races of black and yellow rusts or their mixture in the seedling stage. Varieties N.P. 4 and Proctor were found resistant to all the races of yellow rust, whereas B. 253 and Harungani Brinas were susceptible to most of the races of the two rusts. Also, N.P. 13 was found resistant to a mixture of yellow rust races. In the adult resistance tests, about 550 varieties and crosses, comprising more than 1300 seedlings, were tested in field against black and yellow rusts after creating artificial epidemics and varieties E. C. 6174 a, E.C.6530, E.C.6539, E.C.6542, E. C. 6543 E. C. 6544, E. C. 6547, E. C. 6557, E. C. 6576, E. C. 6578, E. C. 6579, E.C 6585, E.C.6692, E.C. 6708, E.C. 7004, Plumage No. 1, Plumage No. 2 and Denalie remained free from rust infection.

Puccinia hordei, hitherto considered of rare occurrence in India was observed at several places in Madras, U. P. and Delhi State. Two samples of *Puccinia hordei*, which had shown clear differences in rust reaction on some local barley varieties last year, did not show any differences on the standard differentials, indicating thereby that they may be biotypes of the same race.

(b) *Loose Smut* [*Ustilago nuda* (Jens.) Rostr.] : Out of 58 barley varieties tested for their resistance to the disease, varieties B 17, B. 146, B. 164, B. 231, B. 237, N.P. 2 and N.P. 7 did not show any smut infection.

(c) *'Molya' disease* : This disease of barley and wheat has been known to occur in Rajasthan for the last 20 years or so and is at present particularly severe in Sikar and Jaipur districts and to a lesser extent in Ajmer area. Although exact losses due to the disase have not been calculated, rough estimates show that, in barley crop alone, incidence of the disease in certain localities may be as high as 65-80 per cent. It is, however, not so severe in wheat crop. The disease can be easily observed in the field by the presence of pale and stunted plants in patches.

Since cause of the disease is not known, an analysis of large number of soil and plant samples, collected from both healthy and diseased fields at different times, was undertaken. A number of saprophytic fungi and a few parasitic ones *e.g. Fusarium*, *Helminthosporium* and *Pythium* were isolated from all the samples, irrespective of the fact whether they were from diseased or healthy areas. Different stages of a species of *Heterodera* were, however, mostly obtained from the diseased areas, indicating thereby, that this may be the true cause of the disease. Pathogenicity tests with different fungi and *Heterodera* sp. singly and in combination are in progress.

3. *Maize* (*Zea mays* L.) :

(a) *Rust* (*Puccinia sorghi* Schw.) Twelve rust samples, collected from Himachal Pradesh, Punjab and Nilgiris, were tested on 35 inbred lines of maize for physiologic race study. Two samples gave different reactions on the maize variety R. 88, thus indicating the possibility of physiologic specialization within the pathogen.

(b) *Downy mildew* (*Sclerospora phillippinensis* Weston) : Histo-pathological studies of the infected plants of *Kans* (*Saccharum spontaneum*) showed presence of the mycelium of *S. philippinensis* in the underground parts, thus indicating that the pathogen may perennate in this way during the off season. Naturally infected *Kans* plants were, therefore, collected in July, 1955, and planted in pots for observation. During the next monsoon season (July, 1956), these clumps produced new shoots which were chlorotic and were covered with downy sporangial growth of the fungus. Inoculation tests with the *Kans* strain of *S. philippinensis* on maize, however, gave negative results.

4. *Bajra* (*Pennisetum typhoides* Stafl. and Hubbard):

Green-ear disease [*Sclerospora graminicola* (Sacc.) Schroet.]: Oospore material of *Sclerospora graminicola*, after weathering during summer and winter, germinated satisfactorily within 48 hours. All attempts to induce better and quicker germination of Oospores by physical treatments *e.g.* alternate drying and wetting, freezing and thawing and exposure to high temperature (40° C. for 48 hours) as also by chemical treatments *e.g.* soaking in 10% aqueous solution of bleaching powder and 1% aqueous solutions of lactic, acetic and citric acids were unsuccessful.

Investigations on the relative resistance of eleven *bajra* varieties to *S. graminicola* and effect of protective fungicidal seed treatments against the disease were also in progress. In view of the fact that the percentage of infection obtained in the test plots was generally low, no conclusions could be drawn.

5. *Sugarcane* (*Saccharum officinarum* L.):

(a) *Red Rot* (*Colletotrichum falcatum* Went): During the year under report, red-rot in the form of localised epidemics was reported from certain localities of Punjab (Jullundur and Jagadhari), U. P., Bihar and Delhi State and the cane varieties Co. 312., Co. 453, Co. L. 29 and Co. J. 33 were found mainly affected. Isolations from the diseased materials yielded only light type isolates of *C. falcatum*.

In the Physiologic Forms studies, twenty-five isolates of the red-rot fungus (20 light type and 5 dark type isolates), obtained from different localities and various cane varieties, were tested on the ten standard cane varieties (Co. 213, Co. 223, Co. 299, Co. 312, Co. 313, Co. 331, Co. 356, Co. 419, Co. 421 and Co. 445), having different genetic composition, but no evidence of physiologic specificity was obtained.

In the varietal resistance tests, 178 important and promising cane varieties were tested by plug method and 91 by nodal infection method. In the former test, 4 varieties (Co. 939, Co. 966, Co. 1046 and B. O. 30) reacted as resistant, 151 as moderately resistant and the remaining 23 as susceptible. The corresponding figures for the nodal infection test were 1 (Co. 1078), 7 (Co. 312, Co. 1005, Co. 1054, Co. 1070, Co. 1079, Co. 1080, and Co. 1083) and 83.

In the experiment to determine the effect of mixed inocula on red-rot infection, six combinations of light and dark type, light and light type and dark and dark type isolates were tried on the ten standard cane varieties. Six varieties, out of the 10 tested, showed greater infection when inoculated with a mixture of light and dark type isolates (Nos. 244 and 78) than with either of the two isolates separately. Similarly, in the case of isolate Nos. 359(light) and 334 (dark), the mixed inoculum proved more virulent than that of individual isolates in 4 varieties out of the ten used. It was further observed that 5 varieties gave more infection with a mixture of light (No. 359) and dark type (No. 334) isolates as compared to the infection obtained with the mixture of two light type isolates (Nos. 244 and 359). There was, however, no significant increase in infection when the dose of inoculum of a light type isolate was doubled. These results

were in close agreement with those obtained during the previous years in that the mixture of light and dark type isolates gave greater infection in some varieties than the individual strains or mixture of 2 light or 2 dark type isolates.

(b) *Smut* (*Ustilago scitaminea* Syd.) : In the varietal resistance tests, 74 cane varieties at Delhi and 96 at Karnal were tested for their resistance to smut. At Delhi, 5 varieties showed less than 5% infection, 4 showed 5-15% infection, 10 gave 15-30% infection, and the remaining 55 varieties showed 30-100% infection. The corresponding figures for the Karnal experiment were 6,11, 25 and 54. Ten varieties, namely, Co. 1005, Co. 1022, Co. 1023, Co. 1026, Co. 1027, Co. 1034, Co. 1134, Co. 1143, Co. 1147 and B. O. 28, which showed less than 5% infection, may be considered as resistant. Of these again, the first seven varieties had reacted as resistant in the previous tests also and, therefore, appear to be more promising. The maximum infection obtained in these tests was 90%.

(c) *Rust* [*Puccinia kuehnii* (Kerrger) Butler] : The rust was maintained on cut leaves of sugarcane for seven successive generations. The optimum temperature for uredospore germination in distilled water was 18°--25° C and for teleutospore germination it was 18°—22° C. The rusts from *Saccharum spontaneum* and *S. Officinarum* were found to be cross-inoculable. The rust culture from *Erianthus fulvus* also infected sugarcane (*S. officinarum*).

6. *Linseed* (*Linum usitatissimum* L.) :

Rust (*Melampsora lini* (Pers.) Lev.) : Thirty-nine rust samples, obtained from different parts of the country, were analysed and all the five races of *Melampsora lini* already reported were met with. In the seedling resistance tests, ten varieties, namely, E.C. 8702, E.C.8703, E.C. 8704 E.C. 8705, E.C. 9723, E.C. 6163, E.C. 9964, E.C. 9969, E.C. 9971 and E.C. 10663 were found resistant to all the individual races of linseed rust under glasshouse conditions. In the adult resistance tests with 140 varieties or cultures, 66 proved resistant.

7. *Sannhemp* (*Crotalaria juncea* L.) :

Rust (*Uromyces decoratus* Syd.): Further studies confirmed that perpetuation of the rust under Delhi conditions either through uredo-or teleutospores or through dormant mycelium was not possible.

Teleutospore germination studies showed that sporidia were sometimes produced in chains particularly if the conditions immediately after the formation of promycelium were not entirely favourable. Some other abnormalities like the formation of a long, sterile promycelium or the appearance of a bifurcated mycelium from the same spore were also observed.

8. *Pigeonpea* [*Cajanus cajan* (L.) *Millsp.*]:

Wilt (*Fusarium udum* Butler): Of the 20 pigeonpea varieties tested for their resistance to the disease in field and pots, seven varieties (N.P. 41, N.P. 51 C. 15 W.E., S. 34, S. 55, S. 83 and S. 86) showed less than 10% infection, whereas the maximum infection obtained was 73.3%, and may, therefore, be considered as fairly resistant. One of these varieties (S. 55) did not develop wilt in the field, although it showed 5.3% infection in pots.

9. *Antibiosis:*

Work on the *Bacillus substilis* antibiotic was continued. Increased amount of the antibiotic was produced in sterilized soil supplemented either with glucose and asparagin or glucose and some legume plant roots. The wilt disease of pigeonpea was considerably reduced in such soils and it was indicated that the antibiotic acted systematically.

Attempts were being made to isolate the antibiotic and study its properties. Chromatograms could be successfully developed on Whatman No. 1 filter paper, using isoproply alcohol-acid-water (70: 2: 28) as solvent system. The antibiotic could be eluted out with N-butyl alcohol.

10. *Physiology of Fungi :*

Studies on factor affecting virulence of dark and light type isolates of *Colletotrichum falcatum* went were in progress. Inoculation tests on sugarcane indicated that the light, highly sporulating isolate of *C. falcatum* (isolate No. 244) was more virulent than the dark, sparsely sporulating one (isolate No. 78). Furthermore, it was observed that the two cane varieties, Co. 312 and Co. 647, showed considerable difference in the degree of their resistance to *C. falcatum*. A dose of Browns' synthetic medium in advance of inoculation resulted in enhanced parasitic activity of the isolates. Further it was indicated that source of nitrogen was chiefly responsible for this change in activity.

Physiological studies on *Lophotrichus ampulus* Benj. showed that sodium acetate and maltose induced maximum growth, but no sporulation; lactose and salicin, on the other hand, gave profuse sporulation, but feeble growth. Among the nitrogen sources, nitrates and amino acids supported maximum sporulation. The presence of magnesium and calcium in a medium also induced sporulation.

Safflower callus tissue was maintained and carried through 4 generations on white's solid medium containing 0.1 p.p.m. of naphthalene acetic acid. Napthalene acetic acid was found to be essential for the development of normal undifferentiated tissue.

11. *Effects of atomic radiations :*

Effects of radioactive phosphorus and fast neutrons on *Colletotrichum falcatum* were investigated. Three distinct mutants were picked up which maintained their characteristics for a number of generations. One of the mutants of isolate No. 244, obtained with the aid of B radiations from P^{32} at an initial activity level of 240 microcuries per ml., resembled the well known dark type in macroscopic characters, but the spores of this strain were smaller in size and ovate-elliptic in shape as compared to the slightly larger and characteristic falcate spores in the parent culture. The other mutant showed normal growth and sporulation on potato dextrose agar, very restricted growth on oatmeal agar and practically no growth on Richards' medium. There were indications that the mutant had probably some vitamin and salt deficiency. A colour mutant was also obtained with the aid of fast neutrons which formed white spore masses in culture as compared to the characteristic pink masses in the parent culture. Pathogenicity tests carried out with the short spored mutant and the colour mutant indicated that the mutants were slightly more virulent than the parent in sugarcane vairety Co. 647.

Using about 170 microcuries per ml. of initial activity of P^{32}, large number of unstable variants were induced in *Phycomyces blakesleeanus* Burg. From these, however, three fairly stable mutants were picked up by repeated single sporing.

It was further demonstrated that low dosages of B-radiations from p^{32} exerted a stimulative influence on a number of fungi and Actinomycetes in soil. Lower dosages of fast neutrons stimulated growth and spore germination of *C. faicatum* and growth of *Ustilago tritici* whereas, higher dosages had adverse effect in this respect.

12. *Fungicides:*

Laboratory experiments were conducted to test the comparative efficacy of N.I. Ceresan, Arasan, 2% Ceresan, Semesan, Hexasan, Cerenox, Agrosan GN, Harvesan, Lunasan, Fusariol, Flit-406, Tillex, Spergon, Thiram, Phygon, Dow-9B, Agrosan 5W, Fernasan A, Leytosol B and P.C.N.B. against seedborne infection of stripe disease of barley (*Helminthosporium & gramineum*) and stem rot of jute (*Macrophomina phaseoli*). Agrosan GN (0·3%), Fusariol (0·18%) and Agrosan 5W (0·15%) effectively checked the growth of stripe disease organism, whereas N.I. Ceresan (0·4%), Flit-406 (0·4%) and Agrosan 5W (0·4%) proved better against stem rot fungus.

Eighteen spray fungicides, namely, Zerlate, Ziram, Fermate, Ferbam, Parzatedry Dithane Z-78, Thiram, Perenox, Fytolan, Fungicopper Geigy, Cupricol, Coppesan, Blitox, Fungimar, Spraycop 530, Cupramar, Copper oxychloride and tribasic Bordeaux mixture were tested in laboratory for their comparative fungicidal properties at seven different concentrations

in the dose ratio of $\sqrt{10}$ by test tube dilution method with *Alternaria tenuis* as test organism. Six fungicides (Ferbam, Ziram, Fytolan, Cupricol, Fungimar and Perenox) gave good results with "E.D. 50" ranging from 0·00034 to 0·0029%.

Four new formulations, evolved by the Chemistry Division, I.A.R.I., were also screened for their fungicidal properties. Of these, Glycerol thiocyanoacetate proved fairly good, while Ketone derivative and Terpene mercurial derivative exhibited poor fungicidal properties. Sulfurized terpene emulsifiable, however, did not show any fungicidal properties.

In the comparative fungicidal trials in field against Hill bunt of wheat (*Tilletia foetida*) at Simla, N.I. Ceresan, Harvesan, Lunasan, Fusariol, Agrosan GN, Flit-406, P.C.N.B., Hexasan and Tillex were tried as seed dressings. Fusariol (0·2%), Agrosan GN(0·2%), P.C.N.B. (0·18%) & N.I. Ceresan (0·06%) gave 0·5, 0·91, 1·33 and 1·42 per cent infection, respectively, as against 76·67 per cent infection in the control on plant basis The increase in yield was accordingly higher. In the field spray experiments against Tikka disease of groundnut (*Cercospora personata*) with 19 fungicides, three fungicides (Fytolan, Fungimar and Dithane Z-78) gave better results as judged by the disease incidence and yield (pods).

The Aretan treatment of sugarcane setts at the time of planting showed about 23% increase in yield from the plots planted with setts treated with Aretan at the rate of 1 lb. in 10 gal. of water ('In and out dip') as compared to the untreated control.

A mixture of sulphasomidine and sulphagonaidine suppressed the rust pustule formation on the inoculated wheat seedlings which, however, could be initiated again by spraying the plants with folic acid.

13. *Seed Testing:*

Eighty-five seed samples of wheat, obtained through the Regional Directors of Food, were examined for ecto-and endo-phytic fungal flora. All of them were found to be free from any internally or externally borne pathogenic fungi, although some of them were externally infected with some saprophytic fungi *e.g.*, *Alternaria*, *Mucor*, *Rhizopus*, *Curvularia* and *Fusarium* either singly or in different combinations. Seventeen samples of vegetable seeds, collected from local market, were also tested for the same purpose and *Alternaria* sp. from *Brassica campestris* var. *sarson* and *Colletotrichum* sp. from chilli were isolated. Two *Jowar* samples, collected from the standing crop in the Botany Division, yielded species of *Phoma*, *Curvularia* and *Fusarium*.

About 380 samples, intended for export to foreign countries, and 350 samples, received from abroad, were examined and necessary phytosanitary certificates were issued and fungicidal treatment given. Nine samples meant for export were found to harbour pathogenic organisms and were, therefore, rejected.

14. *Assessment of Losses:*

Since there are no authentic estimates regarding the losses caused by plant diseases in the country, a scheme has been recently started to develop techniques for assessing losses. Studies have, in the first instance, been taken on Angular leaf spot of cotton (*Xanthomonas malvacearum*), mosaic and Tikka disease of groundnut (*Cercospora personata*), leaf spot of *jowar* (*Colletotrichum graminicolum*), papaya mosaic and "Kattee" disease of cardamom.

15. *Bacterial diseases of plants:*

(*a*) "*Tundu* (*Yellow ear-rot*) *disease of wheat* [*Coryne bacterium tritici* (Hutchinson) Bergey *et al.*]: Studies on the etiological relationship between the bacterium (*C. tritici*) and the nematode (*Anguina tritici*) were continued. It has not so far been possible to define the relative role of the eelworm and the bactrium in the development of the disease. It appears, however, that the eelworm probably functions as a vector, transporting the bacterium to the meristematic regions of the plants which are normally inaccessible to the bacterium.

There is some evidence suggesting that the bacterium may be able to survive in soil under certain conditions as field observations have clearly shown that, in certain wheat growing areas, bacterial disease alone can be present.

(*b*) *Citrus canker* [*Xanthomonas citri* (Hasse) Dowson]*:* Thirty-three cultures of *X. citri*, isolated from diseased specimens obtained from different parts of the country on six species of *Citrus*, were studied for their morphology, cultural characters, biochemical reactions and pathogenicity, but no evidence of strains within the pathogen was obtained. Further evidence was obtained that the pathogen could not remain viable in soil for long periods and that it declined more rapidly in wet than in dry soils.

Bacteriophages for *X. citri* were isolated from the diseased leaves and from soil beneath the diseased citrus trees. On the basis of plaque morphology, the two phages isolated appeared to be identical. These are now being purified and brought to high titres for further studies.

(*c*) *Bacterial leaf spot of chilli* [*Xanthomonas vesicatoria* (Doidge) Dowson]*:* A bacterial leaf spot of chillies was observed in a severe form in the Botany Division, I.A.R.I., during October, 1956. The pathogen was isolated and identified as *X. vesicatoria*. In host-range studies, 24 plant species belonging to different families were tested, but the pathogen attacked only tomato and chilli. All the twenty-six chilli varieties, tested for their resistance to the disease, were found to be susceptible. The pathogen was found to survive in the diseased leaves for 5 months, in sterilized soil up to 4½ months, and in unsterilized soil for 15 days only. Seed was, however, found to be the main source of primary infection.

Detailed studies on nutritional requirements of the pathogen showed that glucose served as the best source of carbon. Furthermore, it utilised salicin as a source of carbon in the presence of vitamins and yeast extract.

Bacteriophage for *X. vesicatoria* was isolated from the diseased leaves. It is now being purified and brought to high titre for further work.

16. *Miscellaneous:*

(*a*) *Deficiency disease of guava:* Experiments on the control of the disease by foliage spray, soil application and trunk, injection with zinc sulphate were continued. Trunk injection with zinc sulphate cured the branches along the side of the trunk where injections had been given. Injections with metalic zinc, however, did not show any beneficial effect. 'Nu-Z', a Tennessee Corporation product containing zinc, was found to be as effective as Zinc sulphate when used as foliage spray. Experiments were laid out to determine the optimum time, interval and number of sprayings as also the optimum dose for soil application for control of the disease with zinc sulphate.

(*b*) *Cultivation of edible mushrooms under Delhi conditions:* Conditions for the preparation of spawn and production of paddy straw mushroom (*Volvaria volvacea*) were studied. It was seen that watering the beds twice a day, temperature of 86° to 95° F, and application of gram plus *arhar* flour favoured the production of mushrooms. The mushrooms appeared in the form of buttons after 16-18 days of spawn, whereas fully matured mushrooms were obtained within next one or two days. *V. volvacea* gave comparatively more yield than *V. diplasia*.

Potato dextrose agar and oat meal agar were found to be the best media for the maintenance of cultures of the local mushroom at a temperature of 89·6°F. Black gram (soaked and autocalved) as also a mixture of soil, sand, ash, gram flour and potato extract were found to be suitable substrata for the preparation of spawn.

(*c*) *Nematodes in relation to plant diseases:* Thirteen root-knot diseases on various plant species e.g. *Abelmoschus esculentus*, *Luffa cylindrica*, *Memordica charantia*, *Digerea arvensis*, *Celotia argentia*, *Solanum melongena*, *Lycopersicon esculentum*, *Cuminum sativum*, *Dolichos lablab*, *Nicotiana tabacum*, *Cucurbita moschata*, *Vigna sinensis* and *Corchorus* sp. caused by species of *Meloidogyne* were recorded. Analysis of soil samples in connection with the survey of plant parasitic nematodes led to the identification of thirteen nematode species. Furthermore, *Hoplolaimus coronatus*, which is known to cause severe stunting of cotton plants, was isolated from the soils collected from the root zones of severely stunted cotton and chilli plants.

B. Section of Plant Viruses

17. *Bhindi* (*Abelmoschus esculentus* Moench.):

Yellow-vein mosaic: Varietal resistance tests and search for alternative hosts were continued *Abelmoschus manihot* (Portugal) and *A. Crinitus* were found to be immune, while *A. angulosus* showed tolerant reaction. *Corchorus tinctorius, Eclipta erecta* and *Amaranthus* sp., showing yellow-vein mosaic symptoms under natural conditions, did not prove to be the alternative hosts of the virus when indexed on *bhindi*.

18. *Chilli* (*Capsicum frutescens* L.):

Mosaic and leaf curl: *Myzus persicae* was found to be an additional vector of the chilli mosaic virus. In the varietal resistance tests against mosaic disease, varieties *Puri Red, Puri Orange, Cuttack-Red Pendent*, 5402-1, RS 5 and RS 8 appeared to be resistant.

Varietal resistance tests against leaf curl of chilli were also in progress.

19. *Brinjal* (*Solanum melongena* L.):

(*a*) *Mosaic:* The disease was found to be caused by a virus complex, one of which produced systemic mosaic symptoms and the other local mecrotic lesions in *Nicotiana glutinosa*. The virus was transmitted to *Nicotiana grandiflora, N. affinis* and *Physalis floridana* by juice inoculation. It could not be transmitted by *Myzus persicae* and *Aphis gossypii* and was found to retain its infectivity after heating for 10 minutes at 158°F. but not at 167·°F. All the eight *brinjal* varieties tested for their resistance to the disease proved susceptible.

(*b*) "*Little-leaf*" *diseases:* The virus was successfully transmitted by a dodder species, *Cuscuta australis*. Twelve *brinjal* varieties were tested for their resistance to the disease and all, except *Chinese green Long*, proved susceptible.

20. *Sesamum* (*Sesamum indicum* DC.):

Phyllody: The jassid, *Deltocephalus* sp., was found to pick up the virus in the nymphal stage also. The latent period of the virus in the insect was completed on the diseased plant itself if the jassids were allowed to feed on it for adout 3 weeks during June to August. In host-range studies the virus was successfully transmitted to *Crotalaria lanceolata, C. medicaginea, C. retusa, Brassica campestris* var *toria, B campestris* var *sarson* and *Cicer arietinum* through the agency of viruliferous jassids. In the varietal resistance tests, all the 14 seasamum varieies tested either by grafting or through viruliferous jassids or both were found to be susceptible.

The disease incidence in a number of sesamum varieties grown in the Institute area varied from 1·2 to 27·7 per cent.

21. *Cotton* (*Gossypium* spp.):

"*Small-leaf*" *disease:* Three varieties of *Gossypium arboreum*, 1 of *G. herbaceum*, 2 of *G. barbedense*, and 1 each of *G. raimondii, G. anomalam, G. stocksii* and *G. davidsonni* as also eight Indo-American hybrids were tested for their resistance to the disease. All the varieties of *G. arboreum* and *G. herbaccum*, proved susceptible, whereas those of *G. barbadense* and *G. hirsutum* as also the eight Indo-American hybrids showed immunity.

22. *Sugarcane* (*Saccharum officinarum* L.):

(*a*) *Mosaic:* In the insect transmission tests, the virus was successfully transmitted to one out of 25 plants of Co. 313 by *Toxoptera graminum*. A severe type of mosaic, observed in the sugarcane variety Co. 527, is being studied with a view to identify the strain involved.

(*b*) "*Grassy-shoot*" *disease:* The disease was successfully transmitted to healthy setts of Co. 419 by means of the contaminated cutting knife and by juice inoculation of the cut ends of the setts by pinprick method. *Longiunguis sacchari* (*Aphis sacchari*) was established to be a vector of the virus.

In host-range studies by means of the aphid vector, the virus was transmitted to *Sorghum vulgare*, but not to *Zea mays*, *Pennisetum typhoides*, *Pennisetum* sp., *Eleusine coracana*, *Setaria italica*, *Oryza sativa*, *Triticum aestivum Panicum antidotale* and *Saccharum spontaneum*.

23. *Sannhemp* (*Crotalaria juncea* L.):

Mosaic: In host-range studies, a fine-grain mosaic mottle appeared on *Phaseolus vulgaris* minute necrotic lesions on the inoculated leaves of *Datura stramonium* and local chlorotic rings on the inoculated leaves of *Nicotiana tabacum*. *D. inoxia* was not infected at all. The virus seemed to be suppressed in tobacco plants as it could not be recovered on sannhemp.

24. *Chinese Sarson* (*Brassica juncea* Czern. and Coss. Var. *rugosa* Roxb.):

Mosaic studies on host-range and insect transmission were continued. Turnip (*Brassica campestris* var. *rapa*) variety *Purple Top white* and Chinese cabbage (*B. pekinensis*) were successfully infected through the aphid vector, *Brevicoryne brassicae*. *Aphis gossypii* was found to be an additional vector of the virus.

25. *Mung* (*Phaseolus aureus* L.):

Yellow mosaic: Host-range studies were in progress. In addition to *Phaseolus mungo*, *P. aconitifolius* and *Glycine max*, the virus was transmitted to *P. aconitifolius*, *P. lathyroides* and *Dolichos biflorus* through viruliferous white-flies, but not to *Canavalia ensiformis*, *Vigna sinensis* and *Abelmoschus esculentus*. The disease appeared in one out of 20 mung plants raised from the seeds obtained from a diseased plant under glasshouse conditions.

26. *Soyabean* [*Glycine max* (L.) *Merr.*]:

Mosaic: The virus was found to be transmitted by juice inoculation and also through the seed of the diseased plants, the percentage of transmission varying between 2·7 to 7·9. Four species of aphids *viz.*, *Aphis gossypii*, *A. craccivora*, *Myzus persicae* and *Lipaphis ehrysimi* were found to be the vectors. Host-range seemed to be limited to soyabean only. The virus was found to have thermal death-point of 140° to 143·6°F., dilution-end-point between 1:1000 and 1:5000 and longevity *in vitro* of 3 days at 59-98° F and of 5 days at 44·6°—50° F. It was found to be inactivated when infected leaves were desiccated for 8 days or the juice was exposed to ultraviolet light for 2 hours.

27. *Broadbean* (*Vicia faba* L.):

Mosaic: A severe mosaic disease of broadbean, collected from Kulu Valley, was investigated. The disease was transmitted by sap inoculation and by three species of aphids *viz.* *Myzus persicae*, *Aphis laburni* and *Macrosphoniella sanborni*. In host-range studies, the virus was transmitted by sap inoculation to *Vicia tetrasperma*, *V. sativa*, *V. villosa*, *Trigonella foenum-graecum*, *Melilotus alba*, *Trifolium incarnatum*, *Lupinus albus*, *L. annuus*, *L. luteus*, *Pisum sativum*, *Lathyrus odoratus* and *L. sativus*. The dilution-end-point of the virus was found to be between 1:1000 and 1:5000 and it could withstand storage at 42·8°-59° F in *vitro* for 120 hours, but not for 144 hours.

28. *Cardamom* (*Amomum subulatum* Roxb.):

"*Foorkey*" *disease*: The disease was successfully transmitted to *Elettaria cardamomum* (Small cardamom) and *Amomum* sp. (Wild cardamom) by means of the aphid vector (*Pentalonia nigronervosa*), but not to *Zingiber officinale*, *Gladiolus* sp., *canna indica*, *colocasia esculenta*, *commelina* sp., *Sorghum vulgare*, *Triticum aestivum*, *Oryza sativa* and wild turmeric. Thus, the virus was found to be distinct from the "Katte' virus as the latter attacked small cardamom and wild cardamom, but not large cardamom (*A. subulatum*). Wild cardamom serves as a common host for the two viruses.

29. *Papaya* (*Carica papaya* L.) :

(a) *Mosaic* : A search for alternative hosts of the virus was continued. None of the 14 plant species, indexed on papaya, showed presence of the mosaic virus. *Macrosiphum* sp. was found to be an additional vector of the virus.

(b) *Leaf curl* : Experiments to study the relationship, if any, between age of host and infection were in progress. The virus could not be recovered on tobacco and tomato from 9-12 months old papaya plants which had been inoculated but did not show any visible symptoms, showing that the plants had not taken infection. Three papaya plants, infected when young and kept in the glasshouse from August 1955 to Nov. 1956, appeared to have recovered from the disease.

30. *Banana* (*Musa sapientum* Linn.):

Mosaic (or Chlorosis): The virus was repeatedly transmitted from banana to *Cucumis sativus* by mechanical means with the juice extracted in phosphate buffer at pH 7·3, but not through the aphid vector, *Aphis gossypii*. The cabbage aphid, *Brevicoryne brassicae*, did not transmit the disease.

In host-range studies, the virus could not be transmitted to *Nicotiana tabacum* and *Lycopersicon esculentum* by mechanical means and to *Canna indica* and *Curcuma longa* through viruliferous aphids (*Aphis gossypii*).

Out of the sixteen varieties of banana tested for their resistance to the disease through viruliferous *Aphis gossypii* only four varieties (*Tal Chakera*, *China Botha*, *Hajari* and *Musa babzonia* did not taken infection. Varieties *Bargi Bali* and *Kanyal* which did not take infection last year got infected during the year under report.

31. *Gooseberry* (*Physalis peruviana* L.) :

Mosaic : The virus was transmitted by sap inoculation and produced systemic mosaic mottling in *Nicotiana affinis*, N. *grandiflora*, *Solanum nigrum*, *Physalis minima* and *P. floridana*. On *Phaseolus vulgaris*, however, it produced local necrotic lesions.

The virus was found to be infective after heating for 10 minutes at 2°1, 2°F , at dilution of 1 : 1,000,000 and after storage for 9 months at room temperature (72°-112°F) and 45°F.

The virus could not be transmitted by *Myzus persicae*, *Macrosiphum pisi*, *Aphis gossypii* and *A. rumicis*.

32. *Mango* (*Mangifera indica* L.) :

Malformation : Symptoms in mango plants have been observed in two stages, one in the seedling and the other in the inflorescence stage. Symptoms in the seedling stage consist of production of excessive vegetative shoots resulting in bunchy-top appearance of young plants, white in the case of mature trees malformation of inflorescence occurs. Transmission tests by grafting and through insect agency were, therefore, in progress to establish the nature of the disease. Possibility of other causes is also being looked into.

33. *Citrus* (*Citrus* spp.) :

"*Decline*" *disease*. Investigations on a die-back disease of citrus trees, characterised by pronounced veinal chlorosis, chlorotic spotting and twig decline, revealed that the disease was of virus origin. In transmission tests by tissue grafting, the virus was transmitted to standard sour lemon, sour orange and West Indian Key lime. Transmission tests with *Aphis citricidus* were in progress.

34. *Temperate fruits* :

In addition to "Line-pattern" and mosaic diseases of plum, mosaic of *Rubus ellipticus* was established to be of virus origin by grafting. Host-range studies of the three viruses were in progress. "Line-pattern" of plums was successfully transmitted to *Prunus persica*, *P. puddum* and *P. amygdalus*, while plum mosaic to the first two hosts.

Transmission tests by grafting with a suspected mosaic disease of cherries, characterised by variegated leaves and resembling "Marble" mosaic of cherry reported from New Zealand were undertaken.

35. *Development of new strains, serological relationship and cross-immunity studies* :

Seven isolates, obtained as a result of spontaneous mutation in a ring spot strain of potato virus 'X' showed differences in virulence on *Petunia hybrida compacta, Solanum nigrum, Nicandra physaloides, Nicotiana glutinosa* and *Lycopersicon esculentum.*

In the cross-protection tests, it was found that *Dolichos* enation mosaic virus did not multiply in tobacco leaves inoculated with Tobacco mosaic virus, when inoculations with the former were made 6, 8, 12 and 18 days after inoculation with the later, due to unsuitability of the inoculated leaves for the second inoculation. This further confirmed that the two viruses are not related. The Southern sannhemp mosaic virus did not protect sannhemp plants against infection with *Dolichos* enation mosaic virus when different leaves of the same plant were inoculated with the two viruses at the same time. When however, inoculations with *Dolichos* enation mosaic virus were made after intervals of 21, 31, 41 and 51 days, Southern sannhemp mosaic virus gave only partial protection, thus confirming that the two viruses are not related. Similar studies with the mosaic viruses of sugarcane and maize showed that they were related strains of the same virus.

36. *Isolation and purification of plant viruses and study of their properties* :

Fresh samples of Southern sannhemp mosaic and *Crotalaria* mosaic (Delhi strain) viruses were purified and concentrated in distilled water at pH 7 for electron-micrography. *Dolichos* enation mosaic virus was also purified for further studies.

37. *Virus-vector relationship* :

The white-fly *Bemisia tabaci*, was able to carry yellow-vein mosaic virus of *bhindi* and leaf curl virus of tobacco simulataneously. A single viruliferous aphid (*Pentalonia nigronervosa*) was capable of transmitting the virus causing "Foorkey" disease of large cardamom, but at least 50 insects were required to produce cent percent infection.

In case of mosaic of *Brassica juncea* var. *rugosa*, efficiency of the vector (*Brevicoryne brassicae*) was found to increase with a pre-acquisition starvation of ½ to 5 hours, the maximum efficiency being achieved with one hour pre-acquisition starvation period. The efficiency was, however, found to decrease with the post-infection starvation and the virus was completely lost when the viruliferous aphids were starved for 24 hours. The rate of loss of the virus in viruliferous aphids was found to be less when the aphids were starved at low temperature (41°F) than at high temperature (64·4°–86°F). About one-third of the aphids could acquire sufficient virus charge during the course of single feeding puncture.

Even a single viruliferous aphid (*Aphis gossypii*) was able to transmit the chilli mosaic virus. The minimum acquisition feeding period and the minimum inoculation feeding period were found to be 30 seconds. The pre acquisition starvation of the aphids increased the efficiency of the vector when short acquisition feeding periods (up to 5 minutes) were given. The post-infection starvation, on the other hand, decreased efficiency of the vector. Serial transfers of single viruliferous aphids to successive healthy plants showed that the virus was of the non-persistent type. Both alate and apterous forms of the aphid were found to be equally efficient.

38. *Control* :

Experiments on the direct control of the vector (*Bemisia tabaci*) by spraying with different insecticides with a view to check the spread of tomato leaf curl were undertaken both at Delhi and Poona. Spraying with Folidol and Ekatox resulted in low disease incidence, late appearance of the disease and increase in yield as compared to the control.

In the case of "Grassy-shoot" disease of sugarcane, the virus could not be eliminated from the diseased setts of Co. 419 by hot water treatment at 122°F for 2 hours. The setts treated with hot water at 122°F for 4 hours or at 125·6°F for one hour failed to germinate.

39. *General* :

Investigations on mosaic diseases of *Lupinus annuus*, *Nicotiana paniculata*,groundnut and lettuce as also on tomato necrosis, veinal necrosis of beans, "Chirke" disease of large cardamom, "Bunchy top" of banana and sterility of pigeon-pea were in progress.

Mosaic of *Lupinus annuus* was transmitted by juice inoculation to *L.annuus*, *L. albus* and *Phaseolus vulgaris*. The casual virus of the mosaic disease of *Nicotiana paniculata* was identified to be a ring spot strain of the potato virus 'X'. The virus, causing veinal necrosis of beans, was found to be a strain of *Phaseolus* virus 1 and varieties *Kentucky Wonder* and *Earliest of white* showed resistance to the disease. 'Chirke' disease of large cardamom, characterised by mosaic symptoms on leaves, was transmitted by juice inoculation. Mosaic of groundnut was not found to be seed transmitted. Lettuce mosaic was transmitted through seed of diseased plants and by means of *Aphis gossypii* and *A. evonymi*. The virus causing tomato necrosis was successfully transmitted to *brinjal* by grafting.

C. Section of Systematic Mycology :

40. *Taxonomy* :

Critical studies of the genera *Alternaria*, *Helminthosporium* and *Nectria* were made. *Alternaria tenuissima* (Nees ex. Fr.) Wiltshire on *Hibiscus* sp. and *Cajanus cajan*; *A.tomato* (Cke.) Jones on *Hyoscyamus niger* and *A. cheiranthi* (Fr.) Bolle on *Canavalia ensiformis* were recorded for the first time from India. *Lepidium sativum* was found to be a new host record for *A. brassicae* (Berk.) Sacc. A new species of *Alternaria*, allied to *A. macrospora* Zimm., was encountered on *Cyamopsis tetragonoloba*. The species of *Helminthosporium*, occurring on *Eleusine coracana*, appeared to be a new one. *H. siccans* Drechsl. on *Lolium perenne* and *L. temulentum* as also *H. cynodontis* Morig. *on Dactyloctenium. aegypticum* were recorded for the first time in the country. Some nomenclatural changes were affected after a restudy of old specimens of *Nectria* in the Herbarium. For example, *N. bolbophylli* P. Henn. was renamed as *N. haematococca* B. and Br. and *Sphaerostilbe aurantiicola* (B. and Br.) Petch as *N. aurantiicola* B. and Br. A new genus *Chonella*, belonging to Melanconiales was established.

Taxonomic studies on Miscellaneous Indian Fungi were continued and the following fungi of interest, which included 12 new species and 20 new host records for India, were studied. *PHYCOMYCETES* : *Peronospora* sp. on *Cannabis sativa*. *ASCOMYCETES* : *Protomyces* sp. on *Galinsoga parviflora; Achorella* sp. on *Quercus incana*; *Palcostroma* sp. on *Chrysopogon gryllus*; *Pheodothis* sp. on *Anthistiria* sp. ; *Erysiphe* sp. on *Castanopsis indica* and *C. tribuloides* ; *Meloila* sp. on *Rubus ellipticus ; Melogramma* sp. on *Mangifera indica; Ophiobolus* sp. on *Nepeta elliptica; Ophiomassaria* sp. on *Phoenix dactylifera; Diatrypella* sp. on *Rosa* sp. ; *Valsa* sp. on *Rubus* sp.; *Mycosphaerella* spp. on *Ficus infectoria, Digitaria* sp., and *Rumex nepalense; Didymella* sp. on *Agrostis* sp. and *Ascophanus* sp. from soil. *DEUTEROMYCETES* : *Phyllosticta* spp. on *Buddleia* sp., *Ficus carica, Phaseolus aureus and Polyllogonum sp.* ; *Ascochyta rhei on Rheum rhaponticum*; *Ascochyta* spp. on *Solidago* sp., *Solanum tuberosum* and *Marsdenia* sp. ; *Septoria* spp. on *Maesa chisea, Amomum subulatum, Galium rotundifolia* and *Ostodis* sp. ; *Cercospora* spp. on *Daemia extensa, Clematis* sp. and *Osbeckia* sp., *Ustilaginoidea virens on Zea mays* ; *Scolectorichum* sp. on *Tinospora cordifolia; Fusicladium* sp. on *Pimpinella anisum; Monochaeta* sp. on *Carissa carandus ; Ramularia* sp. on *Morina* sp. ; and *Ciliciopus caespitosum on Oryza sativa.*

41. *Herbarium* :

In all, 1,223 mycological specimens (both Indian and Foreign) were added to the Herbarium during the year, bringing the total number of accessions to 25,408. Two hundred specimens as also 18 coloured plates and photographs of important plant diseases were supplied to various Indian and Foreign workers. A large number of mycological specimens, collected locally and received from different sources, were identified.

Regarding exsiccati sets, Fascicle III of 'Indian Uredinales' was completed and is being rpued to important world Herbaria. Another exsiccati set of 'Indian Erysiphales' is under isseparation. World literature on the taxonomy of fungi and a list of specimens available in the Herbarium were being compiled.

42. *Indian Type Culture Collection* :

During the period under report, 96 fungal and bacterial cultures were added to the collection, bringing the total number of cultures to 1,083. About 200 cultures were supplied to various scientific workers and research institutions in the country and abroad. A consolidated list of the cultures maintained in the collection was prepared for publication. Detailed information regarding each culture was being entered in the Descriptive Forms.

Studies on mineral oil and soil preservation of fungi were continued and, out of the 87 cultures preserved in mineral oil, 76 were found viable after a period of about 8 years.

43. *Commonwealth Phytopathological News* :

Four notes providing scientific information on latest researches of interest carried out in India were communicated to the Commonwealth Institute and were published in their quarterly news letters.

Programme of work for 1957-58.

(a) Plant Pathological Investigations :

(i) Studies on cereal smuts and bunts.

(ii) Determination of physiologic races of *Puccinia graminis tritici*, *P. triticina*, *P. glumarum*, *P. sorghi*, *P. simplex*, *Melampsora lini*, *Ustilago tritici*, *Tilletia foetida*, *T. caries*, *Neovossia indica* and *Colletotrichum falcatum*.

(iii) Studies on rusts of wheat, barley, oats, maize, sannhemp, linseed, sugarcane and wild grasses.

(iv) Green-ear disease of *bajra*.

(v) Fruit and vegetable diseases including deficiency diseases.

(vi) Assessment of damage due to certain crop diseases. Aerobiological studies.

(vii) Efficacy of different seed-dressing fungicides ; laboratory, pot culture and field testing of proprietary fungicides and new compounds ; study of ecto—and endophytic fungal flora of stored seeds.

(viii) Testing varieties of crop plants for their resistance to diseases with particular reference to wheat and barley rusts and smuts, bunts of wheat, linseed rust and pigeon-pea wilt.

(ix) *Diseases of sugarcane* : Factors affecting variation in *Colletotrichum falcatum* and recurrence of red-rot epidemics ; role of the perfect stage of *C. falcatum* in the origin of new virulent strains ; virulence of mixed inocula of *C. falcatum* isolates. Evolving of cane varieties resistant to red-rot and smut and studies on the inheritance of their resistance.

(x) Studies on microbial antagonism and antibiotics ; plant tissue culture ; physiology of fungi ; physiology of parasitism of some less specialised plant pathogens ; study of factors affecting virulence of light and dark type isolates of *C. falcatum*.

(xi) *Bacterial diseases of plants* : Yellow ear rot of wheat ; red-stripe of sugarcane ; bacteriophages in relation to bacterial plant pathogens; association of nematodes with bacterial diseases of plants ; surveys of bacterial diseases of fruits and vegetables.

(xii) *Radioactive Isotopes* : Effects of ionising radiations on plant pathogenic microorganisms with particular reference to *Colletotrichum falcatum*, *Ustilago tritici*, bottlegourd mosaic and sannhemp mosaic ; study of the phenomenon of wilting in pigeon-pea (*Fusarium udum*).

(b) Plant Virus Investigations :

(i) Studies on mosaic diseases of *brinjal*, chilli, sugarcane, groundnut, gooseberry, banana, plum, dahlia, *Rubus ellipticus* and *Vicia faba*; yellow-vein mosaic of *bhindi* ; *Dolichos* enation mosaic ; sterility disease of pigeon-pea ; phyllody of sesamum and other oilseed crops as also of *Brassica* spp. ; "Smalling" disease and necrosis of tomato ; leaf curl of chilli and papaya ; "Foorkey" and "Chirke" "diseases of large cardamom ; "Crinkle" disease of cabbage ; "Grassy-shoot" disease of sugarcane ; "Small-leaf" disease of cotton ; mango malformation ; "Little-leaf" of *brinjal* ; "Line-pattern" disease of plum ; marble disease of cherry ; and virus diseases of citrus.

(ii) Fundamental studies on virus-vector relationship of sesamum phyllody, banana mosaic, "Foorkey" disease of large cardamom, "Grassy-shoot" disease of sugarcane and Chinese sarson mosaic. Purification of Southern sannhemp mosaic, *Crotalaria* mosaic (Delhi strain), *Dolichos* enation mosaic, bottlegourd mosaic and *brinjal* mosaic viruses and study of their properties ; inactivation of plant viruses ; movement of potato virus X ; development of new strains and cross-protection tests.

(iii) Control of tomato leaf curl, leaf curl and phyllody of sesamum, papaya mosaic and "Grassy-shoot" disease of sugarcane ; testing varieties of crops for their resistance to diseases *e.g.*, "Yellow-vein" mosaic of *bhindi*, "Small-leaf" disease of cotton, Sesamum phyllody, chilli mosaic, "Little-leaf" of *brinjal* and banana mosaic.

(iv) Survey of plant virus diseases.

(c) Mycological Investigations :

(i) Taxonomic study of new and unidentified collections available in the *Herb. Crypt. Ind. Orient.* ; preparation of exsiccati sets of Indian Fungi, list of fungi deposited in the Herbarium and card-indices of species of fungi represented in India ; collection of world literature on the taxonomy of fungi. Study of Fungal flora of Delhi ; identification of fungi and disease specimens ; taxonomic studies of the genera *Alternaria*, *Cercospora* and *Nectria* ; and maintenance of host index of fungi.

(ii) Maintenance of Indian Type Culture Collection of microorganisms and their history sheets ; study of methods for preservation of fungi and bacteria.

REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING

(Shri J. S. Manku)

General

(1) The following machines and implements were received during the year, for test and trials:—

Sl. No.	Name of Implements/machines	Received from
(i)	Improved Bullock Cart Axle. . .	M/s. National Emporium, Roorkee (U. P.)
(ii)	The Shree Yantra	M/s. K. N. Palshikar Industries Indore.
(iii)	Spinmax Lawn Mower	M/s. Lakshmiratan Engineering Works, Faridabad.
(iv)	One Japanese Ce Co Co Brand Horizontal Kerosene Engine 2.5 H. P. . . .	M/s. Excellent Engineering Co., Bombay.
(v)	One Japanese Ce Co Co Brand Horizontal Kerosene Engine 3.5 H. P.	
(vi)	One Complete Alcee Cultivator fitted with 9 tines with reversable points etc.	M/s. Light Cart, Meerut Cantt.

(2) *Progress of the Recommendation of the Planning Commission and the Agricultural Engineers Conference* : The following schemes have been included in the Division on the basis of the recommendation of the Planning Commission under the Second Five Year Plan.

(a) *Setting up a Museum of Agricultural Implements.* : The Scheme was sanctioned during the first Five Year Plan but due to technical difficulties it could not start functioning. It has now been taken over during the 2nd Five Year Plan period. The building of the Museum which is under construction from last year has not yet been ready but is likely to be completed shortly.

(b) *Setting up a Tractor Testing Station.* : Nagpur has been finally selected as the site for the location of the Tractor Testing Station. Accordingly the Technical Officer in the Tractor Testing Scheme who was working in this Division has been transferred to Nagpur with effect from 12-12-1956.

(c) *Scheme for Production, Demonstration, Trial and Popularisation of Improved Agricultural Implements* : Field testing of the implements and machines, supplied to the State Governments, under the scheme have been completed and the test reports have been received from them in this Division. In order to facilitate the work of compilation of these reports and also to popularise the implements which have been found suitable under different regional conditions, the scheme has been extended for a period of two year from 1-4-1957. A list of improved agricultural implements is now under preparation in consultation with different State Governments.

(d) *Scheme for Survey of Indigenous Agricultural Implements in common use in the Country* : All the States have submitted their Survey Reports during the year. The work of compilation and drafting of All India Report are now in progress. During the meeting of the Agricultural Engineering Committee of the I.C.A.R., a Committee for scrutinizing the reports of the State Governments and to prepare the draft report, was formed. This committee has formed a number of sub-committees and the work has been distributed to them. These committees held several meetings during the year and the preparation of the draft report is progressing satisfactorily.

The I.C.A.R., has also sanctioned a new scheme to survey those implements which were left out in the last survey. The proformas for recording the data have already been prepared.

(e) *Scheme for the Establishment of Research-cum-Testing Centres for bullock driven agricultural implements.*—A scheme for the Establishment of four Research-cum-Testing Centres was prepared by this Division on the basis of the recommendations made by the Planning Commission and the Agricultural Engineers, Conference held in September, 1956 at New Delhi. The objectives of the scheme are (1) to test the bullock drawn implements and machines available and in use in the region under actual field conditions with a view to modifying them, if required, to improve their performances(2) to import implements from foreign countries and to test them under regional conditions; (3) to popularize improved implements; and (4) to design and develop simple and efficient agricultural implements and machines for certain agricultural operations for which no implements exist at present. The scheme was considered by the Agricultural Engineering Committee of the I.C.A.R., in its meeting in October, 1956 and has since been finally approved by the Council. It has been decided that one centre will be located at I.A.R.I., New Delhi and three others at Bombay, Coimbatore and West Bengal respectively. The Head of the Agricultural Engineering Division will act as the Project Coordinator of the work of all the four Research-cum-Testing stations whose work will be coordinated by the I. C. A. R., through the Agricultural Engineering Committee of the Council. The administrative sanction from the Govt. of India is awaited after which the State Govts. will be approached for finalizing the location etc.

Research

1. *Experiments on Cultivating Implements*—

(*a*) *Testing of Hand Operated Hoe :* Three Hand Operated Hoes received from the F.A.O., Rome, were tested along with a Khurpi of our country in the orchards of the Division of Horticulture. The implements were tested in a field with brinjal crop sown in rows 2 ft. apart. The following are the data collected during the trials:—

Sl. No.	Khurpi			Blade type Hand Hoe			Notch type hand Hoe			7-tyned hand Hoe		
	Area of plot	Time taken Mts.	Depth of work	Area of plot	Time taken mts.	Depth of work	Area of plot	Time taken in Mts.	Depth of work	Area of plot	Time taken in Mts.	Depth of work
1	70′×12′	43·00	2″	70′×12′	22.00	2¼″	70′×12′	23.00	1¾″	70′×12′	5·00	2″
2	65′×12′	35·00	2¼″	65′×12′	30.00	1¾″	65′×12′	20.00	1½″	65′×12′	3·00	2″
3	65′×12′	41·00	1¾″	65′×12′	24.00	1½″	65′×12′	24.00	2¼″	65′×12′	4·00	2½″

The 7-tyned hand hoe was found to be an efficient and labour saving implement for the eradication of weeds. It was also tried in a field with cow peas shown in rows 1 1/2 ft. apart with five tynes only. The labourers had to be trained for operating the implements before they were tested in the fields.

(*b*) *Testing of Wheel Hoe :* At the instance of the I.C.A.R., a wheel hoe, termed as an improved intercultural implement was tested by this Division in collaboration with the Division of Agronomy. The implement has been designed and fabricated by Shri V. V. Gokhale of Nagpur and was submitted to the I.C.A.R. for competition under the Scheme for Award of Prizes for improved agricultural implements. The implement is very simple in construction and is made of wood and scrap iron. It can be operated by one man. The implement is equipped with (1) reversible shovel (2) Sweep or broad share (3) Miniature Plough and (4) Mulching rake. The preliminary trials of the implement were conducted in a sugarcane field for mulching

operation with the rake provided for the purpose. A wheel hoe from Punjab was alsoe tested simultaneously for comparision. It was observed during these trials that the output of work with the Punjab Hoe was more than the new implement. Shri Gokhale's hoe was also heavier to work than the Punjab Hoe though the latter worked the soil to a greater depth. The metallic parts of the implement are not strongly built and the front wheel had a tendency to bend during the operations. From the preliminary observations, the implement does not appear to constitute any improvement over the existing hoeing implements. Further trials of the implement are in progress.

(*c*) *Testing of Palshikar's Seed-drill "The Shree Yantra" :* An automatic bullock operated dibbling machine was received from M/s. K. P. Industries, Indore, Madhya Pradesh, for tests. The tests were carried out jointly by this Division and the Division of Agronomy, in presence of Shri Palshikar, the representative of the firm. The preliminary trials of the machine was conducted in a well pulverised land free from weeds and stubbles. It was observed that a lot of earth was being collected in front of the furrow openers and it was dragged along with the machine. The draft of the machine was recorded to be 220 lbs. Some subsequent trials were taken in a pulverised field where the kharif crop had been recently harvested, but stubble infested field for sowing wheat. It was observed that the stubbles got stuck in between the furrow openers and formed a clogging with the earth under seed tubes. The machine was modified by Shri Palshikar to remove this defect. The machine was also tried in well pulverised field free from weeds and stubbles but the results were not better. The draft recorded this time was 194 lbs. as against 140 lbs. of the Punjab Seed-drill which was also tried simultaneously under the same conditions for comparative data. The weight of the machine is $4\frac{1}{2}$ Mds. It is heavy for operation by a pair of bullocks. The price of Rs. 750/- stated by the firm representative appears to be beyond the reach of the average cultivators. The machine will now be thoroughly modified by the firm in the light of the results of the tests carried out.

(*d*) *Trial of Hand Operated Vegetable Seed-drill :* A hand operated vegetable Seed-drill received from the F.A.O., Rome, as a gift, was tried in the orchard of the Botany Division of the Institute for drilling raddish seeds in rows. The preliminary trials, which were conducted in a well pulverized field with ridges, were satisfactory. A simple arrangement has been provided in the machine to calibrate the seed dropping. The drill will now be tried with other vegetable seeds.

(*e*) *Bullock Driven Seed-drill :* With a view to design a cheap, simple and labour saving seeding machine some efforts have been made to design an automatic seed-drill. The seed picking device which is very simple in construction is mounted on a shaft and provides arrangements for seed regulations. The arrangements are such made that various kinds of seeds could be drilled with this machine. The body of the seeder is made of G.I. sheet fitted on a frame and is mounted on two wheels. The furrow opener is of shovel type and provides the choice of various depth of sowing. A single row proto type working model has been made and will be tested for sowing during kharif season. The model is expected to sow cereals as well as grain without making much alteration or addition in the seeding mechanism.

2. *Experiments on Harvesting Machines—*

(*a*) *Testing of Austrian Scythes :* Six Austrian Scythes were received from the I. C. A. R. for tests in this Division. Some of them have been tested for harvesting oats and berseem and a few of the data collected are given below:—

Name of crop	No. of trial	Area of plot	Time taken for harvesting	Remarks
Oat	1	60′ x 60′	35 Mts.	The time includes cutting and collecting of the cut material.
Oat	2	60′ x 60′	40 Mts.	It was observed that about 30% to 40% of the total time was required for collecting the cut material by the operator.

Name of crop	No. of trial	Area of plot	Time taken for harvesting	Remarks
Berseem . . .	1	30′ x 100′	25 Mts. & 38 Sec.	No collecting of the cut material was done.
Berseem . . .	1	44′ x 18′	4 Mts. & 40 Sec.	Two men, one for operating the scythe and the other to collect the cut material. Duties of these men had to be interchanged after some intervals of time.

The scythes will be tested for harvesting fodder, kharif and other cereal, crops like maize, jower, wheat, barley etc.

3. *Experiments on the Threshing and Winnowing Machine :—*

(*a*) *Improvement of Olpad Thresher :* The project for the modification of the Olpad Thresher was taken in hand in order to (1) improve the quality of 'Bhusa' produced by it and (2) make it suitable for threshing other crops also instead of wheat alone.

To achieve the first object the number of discs in the thresher has been increased to 26 from 20, adding two more discs in each of the three existing rows.

The improved Olpad Thresher with 26 discs was tried in the villages simultaneously with the thresher of the old design. The threshing could be done in a shorter time with the improved thresher than with the old one. The following comparative data were collected during the trials:—

Type of Thresher	Total Hrs. worked	Quantity of wheat threshed in lbs.	Draft required to pull in lbs.
Olpad Thresher of original design with 20 discs.	28.00	6560·00	100.00
Modified Olpad Thresher with 26 discs	20.00	6560·00	100.00

The thresher will further be tested for threshing other crops like gram, peas, etc. during next threshing season.

(*b*) *Testing of a Clod Crusher and Thresher :* At the instance of the I.C.A.R., a Clod Crusher and a disc type thresher submitted by M/s. Simplex and Co., Delhi were tested in this Division under the I.C.A.R.'s scheme for the Award of Prizes for improved agricultural implements. The firm claimed that these two implements could be worked individually as well as collectively in combination of both these implements together. Accordingly the clod crusher and the thresher were first tried separately as two different implements and then joined together and worked as a single machine. After a series of tests, it was found that the machine was not at all suitable for clod crushing in either way, *i.e.*, neither with only the clod crushing unit nor in combination of the two.

The machine was tested in threshing wheat in the same way, *i.e.*, first with the threshing unit alone and then in combination of both the implements. The results of threshing were also not found to be satisfactory in comparison to the Olpad Thresher, which is also a disc type thresher and is being popularly used at present.

(*c*) *Testing of the Winnowing Fan :* Four type of Winnowing fans including the one designed and fabricated by this Division were tested to find out their wind velocity at different distances from the blades. The Bihar and the Punjab fans were exhibited in the Implement Mela held here in the month of September, 1956 and were handed over to this Division. The Bombay fan was received in this Division some time back for the Museum.

The results of the tests are tabulated below:—

Sl. No.	Description of winnowing fan tested	Gear Ratio	R.P.M.	Wind velocity in ft./at the distance of		
				4 ft.	6 ft.	8 ft.
1	Panjab Fan with double cycle sprocket and chain drive	64 : 9	320	680	630	220
2	Bombay fan with double reduction gear drive	17 : 2	310	483	509	530
3	Bihar fan with 'V' belt single reduction pulley drive.	5 : 1	210	457	432	348
4	I. A. R. I. fan with single sprocket and chain drive.	6 : 1	300	972	910	658

4. *Experiments on Processing Machine—*

(*a*) *Testing of the Japanese Groundnut Decorticator :* A manually operated groundnut decorticator, imported from Japan, was tried in the Division. The body of the machine is mounted on an angle iron frame and is made of wood. The machine is fitted with a winnower and clean kernals are delivered. The speed of the machine is adjustable but there is no arrangement for adjusting the chain which connects the counter shaft with the main driving shaft and for this reason the machine, though light in weight and well lubricated, is tiresome for operation for a longer period than ten minutes at a stretch by one man.

The trials were conducted with the local variety of groundnut without any gradation. The nuts were dried in the sun for few hours before putting them into the machine. Two men were required during trials, one to operate the machine and other for feeding the nuts into the hopper. The duties of these men had to be interchanged after some time.

The output of the machine was observed to be as follows:—

Quantity of nuts shelled in a day of 8 hrs. in lbs.	Output of Kernals in a day of 8 hrs. in lbs.	Percentage of unshelled nuts in relation to the total output	Percentage of breakage in relation to the whole Kernals
525.60	354.80	4.93	28.50

The overall performance of the machine was satisfactory and it is considered that the machine will be suitable for groundnut growing regions of our country.

(*b*) *Testing of improved Maize Sheller :* Two maize shellers, exhibited by Yugoslavia in the Indian Industries Fair held in New Delhi last year, were purchased and put to test. The body of one of the shellers was made of wood and was workable by hand only while the other one

could be operated by both hand and foot and was made of steel. One man was engaged during the trials in both cases. The following are the results of the trials:—

Test No.	Type of Machine	Speed of crank R.P.M.	Ratio of gear & crank	Output per hr. in lbs.	Man engaged for feeding only (Excluding the operator)
1.	Hand Operated . . .	58	3 : 1	528	One.
	Pedal Operated . . .	53	3 : 1	486	One.
2	Hand Operated. . . .	60	3 : 1	816	Two.
	Pedal Operated . . .	55	3 : 1	690	Two.

5. *Testing of Pumps—*

(*a*) *Trials of 'Simplex' Gear Type Pump :* The gear type pumping unit designed and sumitted for test by M/s. Simplex & Co., Delhi under the I.C.A.R.'s scheme for Award of Prizes for improved agricultural implements, was installed and tested by this Division. Some of the data collected during its trials are tabulated below:—

No. of Test	R.P.M. of bullocks	Lenth of beam	Average draft in lbs.	G.P.M.	Suction Head	H.P. input	H..P output	P.C. of pump efficiency
1	1.25	9-'9"	290.00	24.6	11'-4"	0.673	0.084	12.50
2	1.75	10'-6"	290.00	38.3	11'-3"	1.01	0.13	13.00
3	1.75	10'-6"	270.00	39.4	11'-0"	0.945	0.132	14.00

(*b*) *Trials of 'Simplex' diaphragm type pump :* A diaphragm type pump submitted by the same firm for the same purpose was also put to test. The following are the data collected during the preliminary trials of the pump. The length of beam remained constant at 10/-6" for all tests.

No. of Test	R.P.M. of bullocks	Average draft in lbs.	Actual suction Head	Total suction Head	G.P.M.	H.P. input	H.P. Ouptut	P.C. of pump efficiency
1	5.00	85	6'-6"	11'-6"	16.10	0.85	0.056	6.60
2	5.50	80	6'-6"	11'-6"	5.31	0.88	0.0185	2.10

6. *Testing of Bullock Cart Axles—*

A conventional type axle which is generally fitted with bullock cart was tested along with an improved cart axle and hub submitted by M/s. National Emporium, Roorkee, in order to compute comparative power consumption data under different load and speed. The testing equipment consists of an electric motor driving a pair of 8" diameter roller through a counter shaft and belt pulleys. The speed reduction from motor to the roller shaft is one to 18. These

rollers drive the cart wheels. The following are some of the typical data collected during the trials:—

Type of Axle	Wt. of cart in lbs.	Wt. carried in cart in lbs.	Running time in hours	Speed of cart in miles per hour	Current Consumed in K.W.
Conventional type	954	820	3 Hrs.	2.46	1.75
Do.	954	410	3 Hr.	2.46	1.33
Improved type	954	410	2.00	2.50	1.40
Do.	954	820	2.00	2.21	1.91

One set of wheels with improved axle and hubs has been fitted to a wooden country cart and has been handed over to the Division of Agronomy for field tests.

7. *Testing of N.P.L. Bullock Cart—*

Tests of the Bullock cart designed and submitted for trials by the National Physical Laboratory of India, New Delhi, under the I.C.A.R.'s scheme for the Award of Prizes for improved Agricultural machinery and equipment have been conducted, simultaneously with an ordinary bullock cart and the following observations were made:—

Type of cart	Wt. on axle with the cart man in lbs.	Wt. (pay load) added in lbs.	Speed per hour in miles	Draft in lbs.	Remarks
N. P. L. cart	1112.00	1290.00	2.52	190.00	On Kutcha road.
Do.	1112.00	1290.00	2.52	90.00	On Pucca road.
Do.	1112.00	1720.00	2.52	150.00	Do.
Do.	1112.00	1720.00	2.15	250.00	On Kutcha road.
Conventional cart . .	954.00	1230.00	2.36	75.00	On Pucca road.
Do.	954.00	1230.00	2.44	150.00	On Kutcha road.
Do.	954.00	1640.00	3.35	185.00	Do.
Do.	954.00	1640.00	3.01	92.50	On Pucca road.

During tests it was observed that the NPL cart is not better in any way than the conventional country cart. On the contrary, the country cart has been proved to be better in some respects than the N.P.L. cart.

(*a*) The structural beams of which the bottom of the cart body is built in two parts, held together by 2 bolts each. Under heavy loads there is danger of the joints breaking down while crossing ridges or small channels.

(*b*) In movement forward the hips of the bullocks keep striking against the cart body. The striking is very much more when taking a turn at road bends.

8 *Testing of Cow-dung gas Lamp—*

A series of experiments have been conducted in order to explore the possibilities of utilizing the cow-dung gas for lighting purposes in collabor ation with the Division of Chemistry. During the course of experiments, it has been found that a 3 mantled lamp with air and gas regulator

manufactured by M/s. Bengal Scientific and Technical Works, (Private) Ltd., Calcutta, was producing sufficient bright light for household work and also for reading and writing purposes. This lamp costs Rs. 38 each and is suitable for demonstration in villages where the cow-dung gas plants have been installed.

9. *Intensive Cultivation Scheme—*

Under the Intensive Cultivation Scheme the working of the following machines and implements were demonstrated to the villages:—(1) Mould Board Plough; (2) 5 tyned cultivators; (3) three and 5 row wheat seed-drill; (4) Bullock drawn Reaper; (5) Olpad Thresher; (6) Threshing with tractor and disc harrow; (7) Cow-dung-gas lamp; and (8) Blade Terracer for levelling.

The following are the details of the work done in the villages during the year:—

Ploughing with different implements	559.50	Acres.
Ploughing with Mould Board Plough	96.50	,,
Discing	46.00	,,
Sowing	98.00	,,
Harvesting	65.00	,,
Threshing with Olpad Thresher	3940	Mds.
Threshing with Tractor & Disc Harrow	1056	,,

Programme of Work for 1957-58

1. Development of a bullock drawn Seed-drill for cereals.
2. Development of a Fertilizer placement-*cum*-Sowing machine.
3. Development of a bullock operated leveller.
4. Development of a Power Operated Thresher for different types of crops which are generally dealt with in the Botanical Research.
5. Development of a Hand Operated Dibbler.
6. Improvement of Olpad Thresher.
7. Testing of different types of Pumps and waterlifts.
8. Experiments on determining the suitable mould-boards for bullock operated ploughs.
9. Experiments on spraying machines.
10. Testing of improved bullock-cart axles.
11. Regular Testing and Standardisation work of the Division.
12. Any other item, that might be suggested by the Ministry of Food and Agriculture from time to time.

REPORT OF THE DIVISION OF HORTICULTURE

(Dr. S. M. Sikka)

The Horticulture section of the Botany Division was made a full-fledged Division, under the Second Five Year Plan, with effect from March, 1956. The Division is to conduct researches for the improvement of fruits and vegetables, including their preservation. The Division comprises three Sections, *i.e.*, Pomology, Vegetable Growing, and Fruit and Vegetable Preservation and Canning. The Division is for the present housed in the Botany Division.

The Pomology section of the Division has initiated a number of research projects for exploiting the genetic variability available in fruit trees and for induction of polyploidy and mutations with a view to evolving superior strains. The work on propagation, standardization of root-stocks and hormone sprays has also been started.

The Vegetable Breeder joined only recently, and the work of this section is still in infancy. The preservation section has not yet been started.

There was a severe hail storm accompanied by strong winds on the 20th March, 1957; it affected the experimental orchard adversely.

A brief account of the research work done in different fruit plants is given below:—

Pomology

1. *Survey, collection and evaluation of superior germ plasm* :—

Important Government and private mango orchards at Banaras, Lucknow and Saharanpur were surveyed. The outstanding trees of different varieties of mango were marked. The grafts from these selected trees will be obtained for further trials and multiplication at the I.A.R.I. One plant each of the following varieties has already been received from Khan Sahib Maqsood Ali Khan's orchard, Saharanpur, (1) Zardabi (2) Baramasi (3) Zafrani (4) Prince (5) Mithwa Gazipur (6) Sipia shahpasand (7) Alfan and (8) Husan Ara.

The citrus orchards at Patiala, Attari, Saharanpur, Jullundur and Dhaula Kuan (H.P.) were also surveyed. The budwood of various prize winning varieties of sweet orange, mandarin orange, grape fruit and lemon in All India Citrus show, Delhi (1956) was obtained. The budlings thus raised have been planted in the orchard.

Six cuttings of Rolf and seven cuttings of Hart guava varieties were secured from California (U.S.A.). They were planted in the nursery for rooting.

The varieties Safeda, Seedless, Chittidar, Red Fleshed, Apple-Guava, Lucknow 49 were collected from Allahabad. These varieties were planted in the collection block.

As many as 50 promising grape varieties were collected from different parts of the country and New Zealand. These varieties were further multiplied for trials.

2. *Citrus* :—

(*a*) *Improvement through bud mutations.*—Lemon and grapefruit trees were examined in the experimental orchard with a view to isolating the possible mutants. Some interesting variations of different shapes were observed in citron (*Citrus medica*) fruit. The suspected mutant branches were marked for further progeny trials. In grape fruit trees, some branches seems to have arisen as bud sports. They have been marked for further studies.

3. *Grape* :—

(*a*) *Improvement through hybridization, with special reference to earliness, yield and fruit quality.*—The performance and other morphological characters of the existing seventeen grape varieties were recorded. The time of flowering, growth habit and bearing of different varieties were noted. The work is still in progress. Many varieties were introduced from abroad and from various States of India for trial and the desirable ones will be utilized in breeding programme.

(*b*) *Induction and utilization of polyploidy*.—Research on the induction of colchiploidy in some promising grape varieties has been continued during the year. The grape varieties under treatment are Bhokri, Anab-e-Shahi, Black Prince, Alamwick, Fakhri, Black Muscat and Hussaini. The experiment was initiated in nursery as well as in the field, where the vines are about 4 years old. The colchicine solution of 0·5% concentration was prepared in 10% glycerine--a non-volatile medium which kept the treated area moist. About 221 plants in the nursery and 6 in the field were treated with colchicine. The autopolyploids were identified by their morphological characters and stomata size. Their performance regarding yield and size of berries and fruit quality will be investigated as soon as the treated plants have started bearing. Apart from other abnormalities a teratological, character was observed in a treated plant of variety Habshi. Such an abnormality, either of spontaneous or induced origin, has not been recorded so far in grape. Three distinct leaves emerged in a shoot which developed from a treated bud. This abnormality may be designated as 'pleiophylly'—a teratological character.

4. *Guava* :—

(*a*) *Effect of hormone sprays on vegetative growth, cropping and fruit quality*:—The guava trees of variety sufaida were sprayed with maleic hydrazide and sodium azide (1000, 1500 and 2000 ppm) compounds at the time of full bloom. The effect of the chemicals on flower drop, vegetative growth etc., was recorded in each treatment. The subsequent development or growth of fruits in each treatments is being recorded. Maleic hydrazide was found to be more effective than sodium azide as abscission accelerator. All the flowers dropped in case of maleic hydrazide sprays.

(*b*) *Improvement by selection and hybridization with special reference to yield and fruit quality*:—Seedings of guava, grown over an area of one acre, were subjected to detailed observations regarding yield and quality of fruit. Interesting variations were observed in the winter crop of 1956. The promising strains were isolated on the basis of fruit size, shape, colour, and fruit quality. As many as 18 selections were finally made and these will be kept under study during the next few years. The seeds of these selection were sown in the nursery and the seedlings are maintaining good growth. They will be transplanted in the field in next season for further studies.

5. *Phalsa* :—

(*a*) *Studies on propagation methods* : Hard-wood phalsa cuttings were treated for 18 hours in solutions of growth regulators and were latter allowed to root in sand. The chemicals used were naphthalene-aceticacid, Beta Indoleacetic acid, Beta Indolebutryic acid, Seradix No. 3 and 2, 4,5—Trichlorophenoxyacetic acid. The callus was observed in some of the treated cuttings but latter they all died. No conclusive results were achieved. Soft wood cuttings will now be tried.

6. *Pomegranate* :—

(*a*) *Cytological studies with special reference to the problem of sterility*.—The important pomegranate (*Punica granatum*) varieties were collected from different parts of the country and grown in the experimental orchard. The performance of evergreen Muscat White and Dholka varieties was found to be outstanding as compared to deciduous variety—Kandhari. In Kandhari variety, the fruit setting was very low and fruits were small and acidic. Double flowering variety was evergreen, flowers were very showy and the stamens were absent.

Technique for meiotic studies from pollen mother cell was standardized. Profuse foreign inclusions in cytoplasm, which were previously interfering for recording observation, were eliminated by the new technique. A suitable modified technique for meitotic studies in sterile double flowered and several other varieties from young leaf tip has also been standardized. In preliminary observations, no striking differences were found in the chromosome number of different varieties under study, but the chromosome behaviour needs further studies.

Studies on floral biology, anatomy, and fruit bud differentation of Double Flowered, Kandhari, and Muscat White have been initiated.

7. *Survey and collection of garden tools and implements from different States and their improvement.*— The Division of Agricultural Engineering has received a large number of garden tools and implements from F.A.O. These were sent to this Division for testing their efficiency and to compare them with indigenous implements and tools like *khurpi*. The hand tools received were, spring lever spade, rotary hand hoe, hand seeder, pulling hoe, pushing hoe, three tined hand hoe, hand cultivator and ridger, digging fork, and hand hoe wheel type etc. The working of hand cultivator, hand hoe blade type and notch type were compared with *khurpi* in a weed eradication trial. Hand cultivator was found to be most effective for weeding, recovery of time and labour. Further trials are in progress.

Programme of work for 1957-58

I. Pomology Section

1. Survey, collection and evaluation of superior germ plasm in mango, citrus, guava and grapes.

2. Fruit tree propagation and standardization of rootstock in citrus, mango, guava and phalsa.

3. Effect of hormone sprays on the vegetative growth, cropping and fruit quality of guava, grapes and on male sterility in papaya.

Breeding Superior fruit varieties

4. Improvement, of grape through hybridization, with special reference to earliness, yield and fruit quality.

5. Improvement of guava by selection and hybridization with special reference to yield and fruit quality.

6. Improvement of Citrus fruits through bud mutations.

7. Induction of mutations in Citrus through X-rays, fast neutrons and radio-isotopes.

Cytological and Cytogenetical studies

8. Cytological study of pomegranate varieties (*Punica granatum*) with special reference to the problem of sterility.

9. Induction and utilization of polyploidy for the improvement of grapes with special reference to seedlessness and other desirable qualities.

10. Survey and Collection of garden tools and implements from different States and their improvement. (In cooperation with the Division of Agricultural Engineering.)

II. Vegetable Section

Breeding and Genetics :

1. Survey and collection of indigenous and wild species and varieties of vegetables and assessment of variability in them and their utilization for breeding.

2. Breeding early, mid-season and late varieties of vegetables.

3. Studies on the sex-ratio, floral biology and pollination with special reference to the role of insect pollinators.

4. Study of the economics of hybrid seed production in brinjal and tomato.

Physiological :

5. Studies of the effect of growth regulators in induction of male sterility, and destruction or interruption of apical dominance in cucurbits and cowpea.

6. Study of the effects of chemical sprays on fruit-set in early and late inflorescence in tomato and brinjal.

PART III

APPENDICES

APPENDIX I

GAZETTED STAFF AT THE INDIAN AGRICULTURAL RESEARCH INSTITUTE DURING 1956-57

Directorate

1. Director	Dr. B. P. Pal, M. Sc., Ph. D. (Cantab), FLS., FBS., FNI.
2. Joint Director	Dr. R. S. Vasudeva, D. Sc. (Lond.), Ph. D. (Lond.), D.I.C., F.N.I.
3. Registrar	Shri B. M. Pal, B.A. (from 11-8-56).
4. Accounts Officer	Shri K. C. Gupta, B.A. (from 8-2-57).
5. Librarian	Shri N. N. Chatterjee, B. Sc., Diploma in Librarianship, Proficiency Certificate in French, German and Russian.
6. Assistant Administrative Officer	Shri S. R. Iyer, Higher Cambridge Certificate (from 9-2-57 to 9-6-57) *Vacant*.

Division of Agronomy

1. Head of the Division of Agronomy	Dr. P. C. Raheja, M. Sc., Ph. D., D. Sc.
2. Agronomist	Shri S. Sen, M. Sc.
3. Agronomist	Shri A. R. Khan, B. Sc. (Agr.), M. Sc. (Wiscon), P. G. (Agron.).
4. Agronomist	Dr. J. N. Sharma, M. Sc. (Ag.), Ph. D.
5. Asstt. Agronomist	Shri K. P. Misra, M.Sc. (from 28-8-56 to 28-2-57).
	Shri J. J. Chandnani, M.Sc. (Ag.) (from 1-3-57).
6. Assistant Agronomist	Shri Harcharan Singh, B.Sc., M.Sc., Ph.D. (Kansas).
7. Asstt. Agronomist	Shri Sher Singh, B.Sc. (Ag.), Assoc. I.A.R.I.
8. Asstt. Agronomist (Instructions) (Post created for three months *vide* Ad. 5/9973, dated 2-3-57 only).	Shri K. P. Misra, M. Sc. (from 1-3-57 to 30-5-57).
9. Asstt. Agronomist (Scheme for Simple Fertilizer Trials).	Dr. K. S. Yawalkar, B.Sc. (Ag.), Ph.D., Assoc., I.A.R.I. (from 1-3-56).

Division of Statistics

1. Head of the Section	Dr. P. N. Saxena, M.A., Ph.D. (from 26-7-56).
2. Asstt. Statistician	Shri A. G. Kavitkar, B.Sc., Assoc. I.A.R.I. (from 7-12-56).

Division of Botany

1. Head of the Division	Dr. S. M. Sikka, B.Sc. (Agri.), Ph.D. (Lond.), Assoc. I.A.R.I.
2. Plant Physiologist	Dr. R. D. Asana, M.Sc., Ph.D. (Lond.), D.I.C.
3. Geneticist	Dr. A. B. Joshi, M.Sc., Ph.D. (Contab), Assoc. I.A.R.I.
4. Cytogeneticist	Dr. M. S. Swaminathan, B. Sc., B. Sc. (Ag.), Ph.D. (Cantab), Assoc. I.A.R.I.

5. Systematic Botanist	Dr. D. Chatterjee, M. Sc., Ph.D. (Lond.) (on other duty, the post will be abolished as and when the incumbent will be confirmed elsewhere).
6. Asstt. Plant Physiologist	Shri T. J. Malkani, M.Sc.
7. Asstt. Agrostologist	Shri P. M. Dabadghao, M.Sc. (on other duty).

Division of Soil Science and Agricultural Chemistry

1. Head of the Division	Dr. S. P. Raychaudhuri, M.Sc., Ph.D. (Lond.), D.Sc. (Lond.) (Cal.), F.R.I.C.
2. Physical Chemist	Dr. B. Ramamoorthy, M.Sc., A.R.I. (Lond.), Assoc. I.A.R.I. (from 18-7-56).
3. Biochemist	Dr. N. B. Das, M. Sc., Ph.D.
4. Soil Scientist	Dr. K. V. Satayanarayan, B.Sc. (Ag.), Ph.D., Assoc. I.A.R.I. (from 25-11-55 to 27-8-56).
5. Organic Chemist	Dr. K. C. Gulati, B.Sc. (Hons. Tech.), M.Sc. (Hons.), Ph.D.
6. Fertilizer Technologist	Dr. C. N. Acharya, M.Sc., Ph.D. (Lond.), D.Sc. (Banaras) (on leave preparatory to retirement).
7. Experimental Physicist	Dr. C. Dakshinamurti, M.Sc., Ph.D. (Lond.), D.Sc. (up to 26-7-56).
	Dr. Y. V. Kathavate, M.Sc., Ph.D. (from 25-1-57 F.N.).
8. Asstt. Agricultural Chemist	Shri M. A. Idnani, B.Sc., Assoc. I.A.R.I.
9. Asstt. Soil Microbiologist	Dr. A. Sen, M. Sc., Ph.D., Assoc. I.A.R.I.
10. Asstt. Soil Physicist	Dr. B. T. Mulwani, B.Ag., M.Sc., Ph.D.(Lond.), D.I.C.
11. Asstt. Soil Survey Officer	Dr. T. D. Biswas, M.Sc., D.Phil.
12. Asstt. Soil Survey Officer	Shri R. S. Murti, M.Sc. (Offg.).
13. Asstt. Organic Chemist	Dr. A. R. S. Kartha, M.Sc., Ph.D.
14. Asstt. Soil Chemist	Shri A. B. Ghosh, M.Sc. (from 1-6-56).
15. Asstt. Physical Chemist	Dr. S. C. Das, Ph. D., D Sc. (from 11-12-56).

Division of Entomology

1. Head of the Division	Dr. E. S. Narayanan, M. A., Ph.D. (Lond.), D.I.C., F.R.E.S., F.E.S.I.
2. Systematic Entomologist	Dr. M. G. Ramdas Menon, M.Sc., Ph.D.
3. Insect Ecologist	Dr. S. Pradhan, B.Sc. (Hons.), M.Sc., Ph.D. (Lond.), D.Sc., F.E.E.S., F.E.S.I., up to 4-10-56.
4. Toxicologist	Dr. S. Pradhan, B.Sc. (Hons.), M.Sc., Ph.D. (Lond.), D.Sc., F.R.E.S., F.E.S.I. (from 5-10-56).
5. Asstt. Systematic Entomologist	Shri S. M. Chatterjee, M.Sc.
6. Asstt. Ecologist	Shri H. N. Batra, B.Sc. (Agri.), Assoc. I.A.R.I.
7. Asstt. Toxicologist	Shri S. N. Chatterjee, M.Sc., Assoc. I.A.R.I. (from 8-12-55 to 7-6-57).
	Dr. Rattan Lall, M.Sc., Ph.D., Assoc. I.A.R.I. (from 8-6-56 to 7-6-57).

Division of Mycology

1. Head of the Division	Dr. R. S. Vasudeva, D.Sc. (Lond.), Ph.D. (Lond.), D.I.C., F.N.I.
2. Systematic Mycologist	Dr. B. L. Chona, B.Sc., Ph.D. (Lond.), D.I.C.
3. Asstt. Plant Pathologist	Dr. M. L. Gattani, M.Sc., Ph.D. (Minn.) (on leave out of India).
	Dr. Kishan Singh, M.Sc., Ph.D. (U.S.A.).
4. Asstt. Virus Pathologist	Shri H. S. Sahambi, M.Sc.
5. Asstt. Plant Bacteriologist	Shri S. D. Gera, M.Sc., up to 19-12-56.
6. Herbarium Keeper	Shri R. L. Munjal, M.Sc. (up to 2-6-57).
	Shri J. N. Kapoor, M.Sc., Assoc. I.A.R.I. with effect from 10-2-57.

Division of Agricultural Engineering

1. Head of the Division	Shri R. V. Ramiah, B.E. (Mech.), M.Sc. (Iowa) MASAE, on other duty with effect from 5-10-56.
2. Assistant Engineer	Shri J. S. Manku, B.Sc. (Elec. Mech. Engg.), A.M.I.E., A.I.M.E.
3. Assistant Engineer	Shri R. P. Singh, B.Sc. (Agril. Engg.), M.Sc. (Agr.).

Horticulture Division

1. Horticulturist	Dr. G. S. Randhawa, M.Sc., Ph.D., M.S.A. (Toronto) (from 21-7-56).
2. Vegetable Breeder	Dr. B. Chowdhury, Ph.D. (Melb.), F.R.H.S., from 14-5-57.
3. Asstt. Horticulturist	Dr. Jagpal Singh, M.Sc., Ph.D. (Mich.), U.S.A. (from 20-8-56).
4. Garden Superintendent	Shri Ramesh Chandra, B.Sc.(Ag.).

Agricultural Sub-station, Karnal

1. Asstt. Agronomist	Shri B. D. Gangulee, B.Sc. (Ag.) up to 7-7-56 A.N
	Shri R. S. Gupta, B.Sc., Assoc. I.A.R.I., from 7-7-56 A.N.

Botanical Sub-station Pusa

1. Superintendent	Shri M. D. Nandkeolyar, M.Sc.

Central Vegetable Breeding Sub-station, Katrain

1. Vegetable Specialist	Shri H. B. Singh, M.Sc., Assoc. I.A.R.I.

Coordinated Wheat Rust Control Scheme (Botanical Portion)

Delhi Centre :

1. Wheat Breeder	Dr. G. S. Murti, M.Sc., Ph.D., Assoc. I.A.R.I.
2. Asstt. Wheat Breeder	Shri M. V. Rao, M.Sc. (from 28-11-56).
3. Asstt. Statistician	Shri Daljit Singh, B.Sc., Assoc. I.A.R.I. from 27-12-56.

Simla Centre :

1. Asstt. Wheat Breeder . . . . . Dr. S. P. Kohli, M. Sc., Ph.D., up to 19-11-56.

Indore Centre :

1. Asstt. Wheat Breeder . . . . . Shri V. S. Mathur, M.Sc. (Agr.).

Wellington Centre :

1. Asstt. Wheat Breeder . . . . . Shri V. K. Srinivasan, M.Sc.

Pusa Centre :

1. Asstt. Wheat Breeder . . . . . Shri S. Kedarnath, M.Sc. (on special leave out of India from 12-8-55).

Shri Y. M. Upadhaya, B.Sc., Assoc. I.A.R.I. from 10-12-56.

Coordinated Wheat Rust Control Scheme (Mycological Centre)

Delhi Centre :

1. Mycologist . . . . . Dr. R. Prasada, M.Sc., D. Sc. (Agr.).

Simla Centre :

1. Asstt. Mycologist . . . . . Shri V. C. Lele, M.Sc. (Agric. Bot.).

2. Asstt. Mycologist . . . . . Shri D. P. Misra, M.Sc.

3. Asstt. Mycologist . . . . . Dr. Gopal Swarup, M.Sc., M.Sc., Ph.D., Assoc. I.A.R.I. (from 27-10-57).

Wellington Centre :

1. Asst. Mycologist . . . . . Shri L. M. Joshi, M. Sc.

Plant Introduction and Exploration Organisation (Bot. Portion)

Delhi Centre :

1. Asstt. Botanist . . . . . Shri S. P. Mital, M.Sc., Assoc. I.A.R.I.

Project for Irrigation Investigation

1. Agronomist . . . . . Shri J. J. Chandnani, M.Sc. Agric. from 19-11-55 to 27-2-57.

Dr. Mukhtar Singh, M.Sc. (Agr.), Ph.D., from 28-2-57.

2. Asstt. Agronomist . . . . . Shri R. T. Gandhi, B.Sc. (Agric.), Assoc. I. A. R. I. from 19-11-55 to 31-5-1957.

Project for setting up P. G. Course in Agriculture Extension

1. Agricultural Development Officer . . Shri S. R. Obherai, B.Sc., (Agr.), Assoc. I. A. R. I.

Scheme for Investigation on Weed Control

1. Agronomist . . . . . Shri R. D. Verma, B.Sc. (Agr.), B.Sc. (Hons.) (Edin.).

Tractor Testing Station

1. Technical Officer . . . . . Shri C. Vedantiah, Bachelor's degree in Mech. Eng. upto 21-12-56.

Survey of Indigenous Agricultural Implements

1. Mech. Engineer . . . . . Shri J. R. Badola, B.Sc. (Agric. Engg.).

Scheme for setting up of Seed Testing Station (Botany Portion)

1. Seed Testing Officer . . . . . Dr. N. L. Dhawan, M.Sc., Ph.D. (Minn.), Assoc. I. A. R. I. upto 5-7-57.

Scheme for use of Radio Active Isotopes in Cytogenetic Studies

1. Asstt. Cytogeneticist . . . . . Dr. H. K. Jain, B.Sc. (Hons.), Ph.D., Assoc. I. A. R. I.

Scheme for the Establishment of Unit for Embryoculture

1. Asstt. Cytogeneticist . . . . . Shri S. Ramanujam, B.Sc. (Hons.), Assoc. I. A. R. I. (on special leave for study abroad with effect from 21-2-57).

Cytological studies in Oil Seed

1. Asstt. Cytogeneticist . . . . . Shri S. S. Rajan, M.Sc.

Scheme for improvement of Essential oil yielding Plants at I. A. R. I.

Delhi Centre :

1. Asstt. Botanist . . . . . Shri B. S. Joshi, B.Sc. (Ag.), Assoc. I. A. R. I. (from 14-12-56 F.N.).

Pusa Centre :

1. Asstt. Botanist . . . . . Shri M. G. Joshi, B.Sc. (Ag.), Assoc. I. A. R. I. (from 15-4-57 F.N.).

Katrain Centre :

1. Asstt. Botanist . . . . . Shri P. M. Bhagchandani, B.Sc. (Ag.), Assoc. I. A. R. I. (from 16-3-57 F.N.).

Allahabad Centre :

1. Asstt. Botanist . . . . . Shri L. M. Jeswani, B.Sc. (Agr.), Assoc. I. A. R. I. (from 16-12-56 F.N.).

Chemical Portion, Delhi Centre

1. Chemist . . . . . Dr. Krishna Rao, M.Sc., Ph. D., A. I. I. Sc. (from 31-8-56 F.N.).

Additional Staff for the Plant Breeding and Genetics Section of the Botany Division, I. A. R. I.

1. Geneticist . . . . . Dr. S. P. Kohli, M.Sc., Ph.D. (from 19-11-56 A.N.).
2. Geneticist . . . . . Shri R. B. Deshpande, M.Sc., Assoc. I. A. R. I. (from 14-3-57 F.N.).
3. Asstt. Geneticist . . . . . Shri M. W. Hardas, M.Sc., Assoc. I. A. R. I. (from 23-8-56).
4. Asstt. Geneticist . . . . . Dr. Vishnu Swarup, M.Sc., Ph.D., Assoc. I. A. R. I. (from 8-10-56 A.N.).
5. Asstt. Geneticist . . . . . Shri R. K. Mehta, B.Sc. (Ag.), Assoc. I. A. R. I. from 11-3-1957.

I. C. A. R. Scheme for the Study of Genetic Variability in Algae

1. Asstt. Botanist . . . . . Shri G. S. Venkataraman, M. Sc. (from 28-12-56 F.N.).

Coordinated Maize Breeding Scheme

1. Maize Breeder . . . . . Dr. N. L. Dhawan, M.Sc., Ph.D. Assoc. I. A. R. I. (from 6-7-57).
2. Asst. Maize Breeder . . . . . Shri Amir Singh, M. Sc. (Ag.) from 1-4-56.

Coordinated Scheme for pre-soaking seeds in Nutrient Salts to be conducted at I. A. R. I.

1. Asstt. Physiologist . . . . . Shri S. P. Singh, B.Sc. (Ag.), Assoc. I. A. R. I. (from 17-1-57).

Coordinated Scheme for Citrus Die Back Disease

1. Asstt. Plant Physiologist . . . . . Shri V. S. Mani, M.Sc.

Scheme for Determination of Soil Fertility and Fertilizer use

1. Soil Scientist . . . . . Dr. N. P. Dutta, M.Sc., Ph.D.

2. Asstt. Soil Chemist . . . . . Dr. B. V. Subbiah, M.Sc., Ph.D. (from 14-3-57 on deputation for training in U. S. A. under E. T. A. P. in General Field of Soil Science).

All India Soil Survey Scheme, I. A. R. I.

Delhi Centre :

1. Soil Correlator . . . . . Dr. K. V. S. Satyanaryanan, B.Sc. (Ag.), Ph.D., Assoc. I. A. R. I. (from 28-8-56).

2. Store Officer . . . . . Shri K. C. Gupta, B.A. (upto 7-2-57).

Shri C. S. Jain, B.Com., LL.B. (from 8-2-57).

Bangalore Centre :

1. Soil Correlator . . . . . Dr. S. V. Govindarajan, B.Sc. (Hons.), Ph.D. (Lond.), DIC., ARIC. (from 3-2-56).

Hyderabad Centre :

1. Soil Correlator . . . . . Dr. B. B. Roy, M.Sc., Ph.D. (from 8-1-57).

Burdwan Centre :

1. Soil Correlator . . . . . Shri S. Diger, M.Sc., Dip. Agri. (Calcutta) (from 1-1-57).

Scheme for Working Electron Microscope

1. Asstt. Physicist . . . . . Shri S. C. Mehta, M.Sc. (from 25-4-56).

Scheme for Cartographic Laboratory for Soil Mapping

1. Cartographer . . . . . Shri L. M. Mathur, M.A.

Scheme for Studies on the Chemical Composition and Nutritive Value of Wheat

1. Asstt. Biochemist . . . . . Dr. B. M. Lal, M.Sc., Ph.D. (Scheme terminated from 1-4-57).

Scheme for Expanded Soil Testing Service under Supplement to Operation Agreement No. 4 & 2

Delhi Centre :

1. Special Officer . . . . . Dr. R. V. Tamhane, B.Agr., Ph.D. (Lond.).

Nagpur Centre :

1. Asstt. Soil Chemist . . . . . Shri N. K. Misra, B.Sc., A.I.I.S.T., Assoc. I.A.R.I. (from 10-9-56).

Calcutta Centre :

1. Asstt. Soil Chemist . . . . . Shri B. B. Rudra, M.Sc., Assoc. I. A. R. I. (from 23-10-56).

Poona Centre :

1. Asstt. Soil Chemist . . . . . Shri N. G. Perur, M.Sc. (from 2-4-57 to 26-8-57).

Coimbatore Centre :

1. Asstt. Soil Chemist . . . . . Shri T. R. Srinivasan, B.Sc., Assoc. I. A. R. I. (from 1-9-56).

Ludhiana Centre :

1. Asstt. Soil Chemist . . . . . Shri Bhagwan Das, M.Sc. (from 14-2-57 A.N.).

Sabour Centre :

1 Asstt. Soil Chemist . . . . . Dr. N. R. Dutta Biswas, M.Sc., Ph.D. (from 26-8-56).

Cuttack Centre :

1. Asstt. Soil Chemist . . . . . Shri U. C. Padhi, B.Sc. (Hons.) Assoc. I. A. R. I. (from 26-10-56).

Hamayat Sagar Centre :

1. Asstt. Soil Chemist . . . . . Shri P. M. Joshi, B.Sc., Assoc. I. A. R. I. (from 7-9-56).

Bangalore Centre :

1. Asstt. Soil Chemist . . . . . Shri H. G. Gopala Rao, M. Sc. (from 1-9-56).

Patiala Centre :

1. Asstt. Soil Chemist . . . . . Shri K. L. Nayar, M.Sc. (Ag.) (from 1-9-57).

Trivandrum Centre :

1. Asstt. Soil Chemist . . . . . Shri H. Sankara Subramania, M.Sc. (from 6-10-56).

Gwalior Centre :

1. Asstt. Soil Chemist . . . . . Shri Y. P. Bali, B.Sc. (Hons.), Assoc. I. A. R. I. (from 23-8-56).

Simla Centre :

1. Asstt. Soil Chemist . . . . . Shri P. C. Thakur, B.Sc., Assoc. I. A. R. I. (from 23-8-56).

Delhi Centre :

1. Asstt. Soil Chemist . . . . . Shri P. K. Oomen, M.Sc. (Tech.) (from 1-5-57).

Unit of Physics Scheme

1. Senior Physicist . . . . . Dr. C. Dakshinamurti, M.Sc., D.Sc., Ph.D. (Lond.), F. Inst. P. (Lond.), from 26-7-56 A.N.

Scheme Regarding Research on Insect Physiology

1. Insect Physiologist . . . . . Dr. Rattan Lal, M.Sc., Ph.D., Assoc. I. A. R. I. (upto 7-6-56).

Dr. N. C. Pant, M.Sc. (Ag.), Ph.D. (Lond.), D. I. C. (from 10-8-56).

Termite Scheme

1. Asstt. Entomologist . . . . . Dr. H. J. Bhambani, B.Sc., Ph.D., Assoc. I. A. R. I.

Unit for Biological Testing and Certification of Insecticides

1. Asstt. Entomologist . . . . . Shri M. G. Jotwani, B.Sc., Assoc. I. A. R. I.

Scheme for Establishing a Unit for Storage Pest Ecology

1. Asstt. Entomologist . . . . . Shri P. B. Mukherjee, B.Sc., Assoc. I. A. R. I.

Scheme for Survey of Beneficial Parasites of Pests of Agriculture Crops

1. Asstt. Entomologist . . . . . Dr. B. R. Subba Rao, B. Sc., Ph. D., Assoc. IARI.

Scheme for Entomological Investigation with the Help of Radio Active Isotopes

1. Entomologist . . . . . Shri S. M. Chatterjee, M.Sc., Assoc. I. A. R. I. (upto 7-6-1956).

Dr. Rattan Lall, M.Sc., Ph.D., Assoc. I. A. R. I. (from 8 6-1957).

Scheme for Setting up of Seed Testing Station

1. Entomologist . . . . . Shri H. N. Batra, B.Sc. (Ag.), Assoc. I. A. R. I. (upto 9-10-56).

Shri B. K. Srivastava, M.Sc. (Ag.), Ph.D. (Kansas) (from 10-10-56).

Scheme for Research on Indian Honey Bee at B. S. S. Pusa.

1. Asstt. Entomologist . . . . . Shri Pritam Lall Sharma, M.Sc. (Ag.) (from 1-12-56).

I.C.A.R. Scheme for Explantion of Toxicity Hazards

1. Asstt. Entomologist . . . . Shri Yash Pal Beri, M.Sc. (from 17-12-56).
2. Asstt. Chemist . . . . . Shri R. S. Dewan, M.Sc. (Tech.) from 24-1-57.

Coordinated Plant Virus Research Scheme

Simla Centre:

1. Asstt. Virus Pathologist . . . . . Shri R. N. Azad, B.Sc. (Ag.), Assoc. IARI.

Poona Centre:

1. Virus Entomologist . . . . . Shri P. M. Verma, M.Sc.
2. Virus Pathologist . . . . . Dr. S. P. Capoor, M.Sc., Ph.D.

Eastern Zone, Kalimpong:

1. Virus Pathologist . . . . . Dr. S. P. Raychaudhuri, M.Sc., D. Phil. (Cal.), FLS, Assoc. IARI.
2. Virus Entomologist . . . . . Shri S. N. Chatterjee, M.Sc., Assoc. IARI (from 16-4-1957 F.N.).

Scheme for Coordinated Plant Virus Disease

Delhi Centre:

1. Asstt. Virus Pathologist . . . . . Shri T. K. Nariani, B.Sc., Assoc. IARI.

Simla Centre:

1. Asstt. Virus Pathologist . . . . . Shri M. L. Seth, M.Sc. (from 22-2-56).

Scheme for the use of Atomic Energy Plant in Pathological Research

1. Plant Pathologist . . . . . Dr. M. R. S. Iyengar, M.Sc., Ph.D. upto 9-1-57.
2. Asstt. Plant Pathologist . . . . . Shri B. S. Bajaj, M.Sc.

Scheme for the study of Bacterial Plant Pathogens

1. Plant Bacteriologist . . . . . Dr. M. K. Hingorani, B.Sc., Ph.D., Assoc. I. A. R. I.

Scheme for setting up of Seed Testing Station

1. Plant Pathologist . . . . . Dr. D. Suryanarayan, M.Sc., D.Sc. (Agra) (from 15-9-56).

Scheme for the appraisal of losses due to Plant Disease

1. Mycologist . . . . . Shri R. L. Munjal, M.Sc. (from 3-6-57).

Central College of Agriculture

1. Principal . . . . . Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C., F.R.E.S., F.E.S.I.
2. Lecturer in Agriculture . . . . . Shri K. P. Misra, M.Sc. (Ag.) (upto 27-8-56).
   Shri Diwan Singh, M.Sc. (Ag.) (from 28-8-56).
3. Lecturer in Chemistry . . . . . Dr. W. V. B. Sundra Rao, B.Sc. (Hons.), Ph.D., Assoc. I.A.R.I.
4. Lecturer in Entomology . . . . . Vacant.
5. Lecturer in Physics . . . . . Dr. Y. V. Kathavate, M.Sc., Ph.D. (upto 24-1-57)
   Vacant.
6. Lecturer in Agricultural Engineering . . . Vacant.
7. Lecturer in Vety. Science . . . . Dr. Gian Singh, L.V.P. (Hons.), P.G. Mukteswar.
8. Lecturer in Horticulture . . . . . Dr. G. S. Randhawa, M.Sc., M.S.A., Ph.D. (Toronto) Ph.D. (Mich.) (upto 20-7-56).
   Shri N. Nath, B.Sc. (Distin.), M.Sc. (Cal.) (from 21-2-57).
9. Lecturer in Mycology . . . . . Dr. D. Suranarayana, M.Sc., Ph.D. (upto 14-9-56).
   Shri S. D. Gera, M.Sc. (from 22-12-56).
10. Lecturer in English . . . . . Shri S. L. Vachar, B.A. (Hons. in Econ.), M.A.
11. Lecturer in Economics . . . . . Shri A. S. Kahlon, M.A.
12. Lecturer in Botany . . . . . Shri B. S. Fozdar, M.Sc.

I. A. R. I. Dispensary

1. Civil Assistant Surgeon . . . . . Dr. R. L. Handa, M.B.B.S. (upto 9-5-1957).
   Dr. R. K. J erath, M.B B.B. (from 10-5-1957 F.N.).

APPENDIX II

Training of Students and Research Workers during 1956-57

(a) List of students awarded the post-graduate diploma

Name of the student	Subject of thesis
Division of Agronomy	
1. K. N. Rout	Effect of placement and fractional application of sulphate of ammonia to wet land paddy.
2. R. K. Tewari	Response of linseed to application of fertilizers in conjunction with manganese and boror.
3. N. Mitra	Efficiency of selective herbicides for control of weeds in Rice Crop.
4. J. Bajpai	The relative efficiency of various nitrogenous fertilizers on the Rice crop.
5. M. N. Akhade	Effect of time of application and levels of N & P on tomato.
6. N. Mahapatra	Effect of cultural cum manurial cum irrigational treatments in the yield of sugarcane.
7. Ranbir Singh	Response of berseem to application of farm yard manure and superphosphate single and in various combinations.
8. B. G. Batkhal	Influence of various levels of nitrogen, phosphate and molybdenum on cauli flower.
9. M. M. Gupta	Studies on the relationship of delta and depth of irrigation and levels of nitrogen and seed rates on wheat.
10. Y. D. Sharma	Phosphate fertilization of berseem with and without potash and/or nitrogen.
11. V. N. Bodade	Interrelationship of delta and depth of irrigation and levels of nitrogen on potash.
12. M. B. Patil	The effect of tillage in relation to levels and placement of fertilizers on carrot crop.
13. S. N. Mehta	Efficiency of nitrogenous fertilizers in relation to wheat.
14. W. C. Bonde	Response to different levels of farm yard manure and its time of application in wheat.
15. D. N. Puri	Response to sources and levels of nitrogen in combination with different doses of phosphate on wheat.
16. F. M. H. Khalisi	Differential response of wheat varieties to fertilization with nitrogen, phosphate, potash and their combinations.
Division of Botany	
17. C. Kempanna	Cytological inter-relationships between ten chromosome forms of Brassica.
18. K. D. Singh	The Botanical classification of garden and field peas grown in India.
19. S. G. Ahire	The utilization of male-sterile mutants for the exploitation of hybrid vigour in tomato.

Name of the student	Subject of thesis
20. R. N. Mohanty	Cytological effects of low radiation of 32P on some cereals and legumes.
21. M. N. Someshkka Riah	Study of drought resistance and related characters i wheat varieties.
22. D. Mukherji	Genetic variability in *Cajanus Cajan*.
23. S. K. Jain	Incidence and induction of pollen sterility in some crop plants.
24. L. B. Lakhani	Genetic analysis of certain interspecific and intervarietal crosses of wheat with special reference to rust resistance.
25. D. Ray	A study of some plant characters in relation to drought resistance.
26. R. K. Mehta	Induction and study of Polyploidy in some fodder plants.
27. B. R. Murty	Cytological studies in some species and hybrids of *Nicotiana*.
28. T. V. Kaushikkar	Genetic variability in quantitative characters in Linseed (*Linum usitatissimum*) at different locations.
29. A. K. Sarma	Studies on the general combining ability of inbred lines of Maize.
30. Miss S. Ghose	Inheritance of rust resistance and some other characters in wheat.
Division of Soil Science and Agricultural Chemistry	
31. Ram Paul Dhir	Phosphorus status of Major Indian Soils—Effect of Flooding Organic Matter and Cations.
32. R. J. Landey	The role of different soil reaction (PH) and availability of plant Nutrients, Phosphorus and Potassium.
33. N. G. Namjoshi	Study of the Properties and formation of Black Soils as affected by parent rocks.
34. H. B. Basavanna	Studies on Laterites and related soils of West Coast.
35. G. N. Mitra	Studies on the interaction of clay and clay minerals and their significance in the determination of mineralogical composition of clays.
36. M. L. Kaul	Study of soils at different altitude in Kashmir State.
37. P. M. Mehta	Nitrogen fixation in Indian soils in relation to Phosphates availability.
38. Y. P. Gupta	Chemical Composition and Nutritive Value of Maize as effected by different manures and Fertilizers.
39. R. B. Rewari	Effect of indegenous Phosphates on Nitrogen fixation by Guar as Green Manure and subsequent utilization of nitrogen by the succeeding wheat crop in Delhi soils.
Division of Entomology	
40. Miss S. Kanakavalli	Studies on some Indian Coccinellidae (Coleoptera) with special reference to the morphology of their terminalia.

Name of the student	Subject of thesis
41. S. D. Misra	Bioassay of stomach poisons to the different stages of desert locust, *Schistocerca gregaria* (Forsk.).
42. S. K. Das	Efficiency of systematic insecticides in the control of some India crop pests.
43. R. L. Sharma	Factors affecting the rate of reproduction in *Bracon* (*Microbracon*) *brevicornis* Wesm. (Braconidae : Hymenoptera), an ectophagous larval parasite of the pink bollworm, *Pectinophora* (*Platyedra*) *gossypiella* Saund. (Gelechidae : Lepidoptera).
44. Saran Singh	The effect of density upon the fecundity of *Callosobruchus chinensis* (L.).
45. B. L. Bhamburkar	Development of *Chilo zonellus* Swin. under variable temperatures.
Division of Mycology and Plant Pathology	
46. G. P. Singh	Studies on the antibiotic substance produced by *Bacillus subtilis*. Biological activity in Plant and Soil.
47. M. R. Siddique	Inheritance of Pathogenicity and mode of infection in Safflower Rust.
48. Trilochan Singh	Interrelationships between soil fungi and plant growth : transformations of plant growth substances by soil fungi.
49. D. G. Rao	Further studies on Inhibitition of Potato virus X.
50. C. S. Krishnamoorty	Studies on the Perithecial stage of *Macrophome* sp. and its Mutant causing leaf spot and Twig Blight of Mango.
51. M. D. Mishra	Life history of *Albugo bliti* and toxonomy of *Albugo* spp. occuring in Delhi.
52. Y. P. Rao	Studies on the strains, survival and control of *Xanthomonas citri* the casual organism of citrus canker.
53. R. N. Prasad	Zinnia mosaic.

(b) Students admitted during the year.

Agronomy

1. A. R. R. Belsare.
2. A. S. Patel.
3. B. H. Bhatt.
4. B. Mandal.
5. B. N. Gangopadhya.
6. C. S. S. Rao.
7. G. M. Karemore.
8. Guremel Singh.
9. I. A. Thomas.
10. K. K. Murthy.
11. K. K. Saxena.
12. L. N. Chakarvarty.

13. M. D. Morey.
14. M. L. Bhendia.
15. M. M. Sawhney.
16. M. M. P. Srivastva.
17. M. S. Sahoo.
18. N. A. Awatramani.
19. N. M. Sahai.
20. P. K. Chanda.
21. P. K. Chaterjee.
22. P. M. Jakate.
23. R. L. Gautum.
24. R. S. P. Srivastava.
25. S. Sadanandan.
26. S. L. Kanoje.
27. S. S. Khera.
28. J. Pattnaik.
29. M. P. Panchbhai.
30. M. P. Shah.

Botany

31. A. P. Chaudhri.
32. P. K. Patel.
33. K. S. Parmar.
34. A. K. Bose.
35. G. A. Katwe.
36. N. M. Nayar.
37. A. P. Ekbote.
38. M. Ramarao.
39. G. B. Pattanaik.
40. G. R. K. Sastry.
41. R. G. Thakare.
42. T. D. Jha.
43. Jaweed Ashraf.
44. B. N. Sahay.
45. N. R. Nair.
46. K. K. Jain.
47. N. Meharchandani.
48. M. P. Alexander.

Chemistry

49. R. L. Karale.
50. A. R. Kalbande.
51. M. V. Kanzaria.

52. V. Gopalaswami.
53. S. M. Umar.
54. C. K. Rajagopal.
55. M. V. Chayannlu.
56. T. V. B. Pillai.
57. S. Venkatachalam.
58. V. K. Saolapurkar.
59. S. P. Gawande.
60. S. S. K. Nanda.
61. K. K. Vyas.
62. S. Prasad.
63. Gurcharan Singh.
64. H. Eshwarappa.
65. Pabitra Pran Barooah.
66. S. K. De Datta.
67. S. B. Deshpande.
68. B. K. Sinha.
69. D. Subba Rao.
70. B. N. Acharya.
71. P. L. Deshmukh.

Entomology

72. Miss N. Khot.
73. N. R. Ananthakrishnan.
74. M. N. Borle.
75. K. Gopinath.
76. Afsarul Hakk.
77. G. G. Kundu.
78. G. Rout.
79. J. P. Sahu.
80. P. B. Suchak.
81. R. Vishwanathan.
82. M. A. Holkar.

Mycology

83. V. Rajendran.
84. P. K. Sengupta.
85. H. O. Agarwal.
86. B. B. Boombe.
87. B. K. Chandrasekhar.
88. B. C. Dave.

89. C. Laxminarayanan.
90. S. S. Quiniones.

c) Plant Protection Course.

91. S.K. Das.

(d) Students admitted for the 3 months course on the use of radio-active isotopes in Agriculture.

1. T. A. Davis.
2. M. S. Choudhuri.
3. S. C. Chakravarti.
4. Dr. P. P. Sinha.
5. Dr. G. B. Gupta.
6. Dr. H. K. Jain.
7. R. S. Dewan.
8. G. W. Rahawalkar.
9. B. S. Bajaj.

(e) Students admitted for other short courses.

Agronomy

1. Debaraj Pande
2. Sukhendu Bikash Mohanty
3. Birajakanta Misra
4. Debendranath Das
5. Gunanidhi Bal
6. Gagan Chandra Chaterjee
7. Harihar Bahinipaty
8. Abdul Zafar Fazal Rab
9. Pravakar Pania
10. Niranjan Patnaik
11. Baikantha Nath Mahapatro
12. Mohendra Nath Das
13. Ranidera Nath Misra
14. B. Sahoo
15. Jayanand Jha

Botany

16. K. B. Jindal

Chemistry

17. Harikrishnan Das
18. Rudra Narayan Misra
19. G. Ramchandran
20. H. S. Nathan
21. C. S. Bahl
22. J. N. Satapathi
23. N. Mitra
24. V. V. Badigar
25. Miss P. G. Leelama
26. B. T. Dabir

Mycology

27. H. S. Nema
28. A. S. Rawat
29. Hari Singh
30. Mrs. B. Kamala
31. M. Dinakaran

(f) Honorary Research Workers.

Botany

1. Thamby Ninan
2. K. A. Patel
3. O. H. Siddique

Mycology

4. Dr. G. R. Mankan

Chemistry

5. M. N. Sadaphal
6. P. S. Bhaduria
7. Horst Folster
8. P. Ramkrishna
9. K. V. Paliwal

(g) Research Scholars.

1. O. H. Siddique
2. Miss S. Kanakanalli
3. D. N. Puri

} Ministry of Education and Scientific Research, Government o India. Research Scholars.

4. S. Bhaskaran
5. S. S. Chamla
6. M. V. Rama Rao

} I. C. A. R. Research Fellows.

APPENDIX III

List of Publications during 1956-57

1. Ahuja, M. R. and Natarajan, A. T. . 1957 Chromosome number of some common plants. Curr. Sci., **26** : 117.

2. Badola, J. R. and Manku, J. S. . . 1957 Deshi Hal Main Sudhar. Kheti, **9**(9), 26-28.

3. Bains, S. S. . . . . 1957 Fertilize the legume in the rotation. Indian Fmg. **7**(2):29-31.

4. Banarjee, R. M. and Das, N. B. . . 1957 Studies on the nutritive value of Indian wheat, Part II. Ann. Biochem., 17:19-22.

5. Batra, H. N. . . . . 1956 Certain pests of fruits likely to be introduced in India from the N. W. F. A. (West Pakistan). *Indian J. Ent.*, **18**(1):63-75.

6 Beament, J. W. L. and Rattan Lal . 1957 Penetration through the egg-shell of *Pieris brassicae* (Linn.). Bull. ent. Res., **48**(1):109-25.

7. Bhaduri, P. N. and Natarajan, A. T. 1956 Studies on the effects of nitrogen mustard on chromosomes in somatic and gametic plant tissues. *Indian J. Genet.*, **16**:8-23.

8. Bhaduri, P. N. and Natarajan, A. T. . 1957 Studies on Chromosomal biotypes in *Khapli* wheat. *Indian J. Genet.*, **16**:77-84.

9. Bhaduri, P. N. and Natarajan, A. T. . 1957 The Punjab wheat C-591, a chromosomal mutation. *Indian J. Genet.*, **16**:85-87.

10. Biswas, T. D. . . . . 1955 Study of manganese in soil profiles. *Proc. nat. Acad. Sci. India*, 24(*A*):588-590.

11. Biswas, T. D. and Das, N. B. . . 1957 Amino acids in soil growing berseem. *J. Indian Soc. Soil Sci.* 6:31-37.

12. Chandra Sekhara, M. R. and Sundara Rao, W. V. B. 1956 Studies on foliar diagnosis II. Leaf composition of the differently fertilized barley crop in the Old Permanent Manurial Experimental Plots (Bihar) and its relation to yield and fertiliser treatment. *Indian J. agric. Sci.*, **26**:243-258.

13 Dakshinamurti, C. and Mehta, S. C. . 1957 Studies on the cathode layer enrichment in the analysis of micro-element in soils. *Proc. 44th Indian Sci. Congr.*, Pt. III 83.

14. Dakshinamurti, C. and Rama Moorthy, B. 1956 The choice of the arc segment suitable for the quantitative estimation of micro-elements by the Cathode layer arc technique. *Nat. Inst. Sci. India. Bull.* **8**:5-8.

15. Das, S. C. . . . . 1956 An X-ray investigation of mineralogical composition of some soil clays. *J. Indian Soc. Soil Sci.*, 135-137.

16 Dhamija, O. P., Murthy, R. S. and Raychaudhuri S. P. — 1956 Cinchona soils of West Bengal. *J. Indian Soc. Soil Sci.*, 4 : 276-283.

17 Dhamija, O. P., Murthy, R. S. and Raychaudhuri, S. P. — 1956 Sudies on soils growing paddy. *J. Indian Soc. Soil Sci.*, **4** : 193-204.

18 Duggal S. P. and Kartha, A. R. S. — 1956 Antioxidants for edible oils from indigenous Myrestica species. *Indian J. agric. Sci.*, **26** : 391-400.

19. Ganguly, B. D. & Relwani, L. L. — 1957 Choose your fertilizers for paddy. Indian Fmg. March 1957.

20. Gupta, Y. P. and Das, N. B. — 1955 Amino acid content of pure strains of Indian pulses. I. Methionine, cystine, and tryptophane. *Ann. Biochem.*, **15** : 75-78.

21. Gupta, Y. P. and Das, N. B. — 1956 Amino acid content of grasses and legumes. *Indian J. Agric. Sci.*, **26** : 373-379.

22. Jeswani, L. M., Deshpande, R. B. and Joshi, A. B. — 1956 Inheritance of some fruit characters in chilli. *Indian J. Genet.*, **16** : 138-43.

23. Joshi, A. B. and Hardas, M. W. — 1956 A chromosome number new to *Linum*. *Nature*, **178** : 499.

24. Joshi, A. B. and Hardas, M. W. — 1956 Alloploid nature of *Okra, Abelmoschus esculentus* (L). Moench. Nature, **178** : 1190.

25. Joshi, A. B. and Hardas, M. W. — 1956 Ploidy in two Bignoniaceous garden climbers *Indian J. Genet.*, **16** : 57-59.

26. Kahlon, A. S. and Randhawa, G. S. — 1956 Some considerations for research in marketing horticultural products in India. *Indian J. Horti.* **13** : 198-208.

27. Kahlon, A. S. and Randhawa, G. S. — 1957 Effects of marketing technology on Citrus industry in India. *Indian J. Horti.* **14** : 30-41.

28. Kartha, A. R. S. and Narayanan, R. — 1956 Development of oil in the ripening coconut. *Indian J. agric. Sci.*, **26**:319-329.

29. Khan, A. R. — 1956 Potatoes fare better with fertilizers. Indian Fmg. **6**(7) : 31-32.

30. Khan, A. R. — 1957 Effect of variation in the depth of cultivation with alternative doses of fertilizers on the yield of potato. Paper read at the Potato Res. Workers' Conf. I. C. A. R., Simla, June 1957.

31. Khan, A. R. — 1957 Varietal performance in relation to nitrogen doses (Sugar). *Indian J. Sug. Res. Dev.* **1** (3) : 3.

32. Malkani, T. J. and Vaidya, S. M. — 1956 Morphological characters of shoot and root in relation to lodging in three varieties of wheat. *Indian J. Genet.*, **16** : 121-33.

33. Manku, J. S. and Singh, R. P. . . 1957 Dhan-*ki*-Kheti-*ke*-Japani Yantra.
Kheti, **9**(9), 88-90.

34. Manku, J. S. and Shiv Dayal . . 1957 Japanese Rice Hullers.
Indian Fmg. **7**(3), 16-18.

35. Mann, H. S. . . . . 1956 Studies on the effect of different levels of moisture and nutrients on wheat.
Indian J. Agron. **1**(2) 81-93.

36. Mehta, S. C. and Dakshinamurti, C. 1957 Nicotinic content in tobaccos.
Proc. 44th Indian Sci. Congr., Pt. III, 52.

37. Mukherjee, T. S. . . . . 1957 Phaslon-*ki*-Katai-*ke*-Yantra.
Kheti, **9**(9), 54-55.

38. Murthy, R. S. and Raychaudhuri, S. P. 1957 Alkalinity problems in soils irrigated by sullage water.
Proc. 44th Indian Sci. Congr., Part III, 86.

39. Narayanan, E. S. and Bhambhani, H. J. 1956 Effect of reduced pressure on *Tribolium castaneum* Host. (Tenebrionidae : Coleoptera).
Indian J. Ent., **18** (2) : 196-98.

40. Narayanan, E. S. and Chacko, M. J. 1957 Superparasitism in *Trichogramma evanescens minutum* Riley (Hymenoptera : Trichogramatidae), an egg parasite of sugarcane and maize borer in India. I.
Effect of Superparasitism. *Proc. Indian. Acad. Sci.*, **45**(B) : 122-28.

41. Narayanan, E. S. and Kundan Lal 1956 Studies on Indian Ichneumonidae (Hymenoptera) Pt. V. Subfamily Pimplinae, Tribes : Xonidini, and Poemenini.
Indian J. Ent., **18**(1) : 29-33.

42. Narayanan, E. S. and Kundan Lal 1957 Studies on Indian Ichneumonidae, Pt. I. Subfamily Plectricinae and Pt. II. Subfamily Collyrinae.
Proc. Indian Acad. Sci., **45** (B) : 86-90.

43. Narayanan, E. S., Pradhan, S. and Bhambhani, H. J. 1956 Relative efficacy of some common fumigants against insects in presence of wheat.
Indian J. Ent., **18**(3) : 296-299.

44. Narayanan, E. S., Subha Rao, B. R. and Sharma, R. L. 1957 Factors affecting rate of reproduction of *Bracon brevicornis* Wesmael.
Proc. 44th Indian Sci. Congr., Pt. III. 397.

45. Narayanan, E. S., Subha Rao, B. R. and Kaur, R. B. 1957 Notes on the biology of the parasites of the leaf mines of citurs plants.
Proc. 44th Indian Sci. Congr. Pt. III. 396-97.

46. Narayanan, R. and Kartha, A. R. S. 1956 The solid iso-oleic acid contents of some natural fats.
J. Sci. Indus. Res., India, 15(B) 368-375.

47. Natarajan, A. T. and Ahuja, M. R. 1957 Cyto-taxonomical studies in the genus *Lantana*.
J. Indian Bot. Soc., **36** : 35-45.

48. Pal, B. P. . . . . 1957 N. P. 710 the Cosmopolitan Wheat.
Ind. Farming, Oct. '57.

49. Pal, B. P. . . . . 1957 Atomic Energy in India—Peaceful application in Agriculture, Potential use in industry.

Major Industries of India *Annual Vol.* **6** : 1956-57 ; 303-310.

50. Pal, B. P. and Sikka, S. M. . . 1957 Breeding crop varieties resistant to diseases and pests in India.

Proc. Internat. Genet. Symposia (Japan, 1956); pp. 435-41.

51. Pal, B. P., Sikka, S. M. and Rao, M. V. 1956 Inheritance studies in wheat.

Ind. J. of genet .16(1) : pp 32-46.

52. Pal, B. P., Sikka, S. M. and Singh, H. B. 1956 Improved Pusa Vegetables.

Ind. J. Hort. **13** : 64-73.

53. Pal, B. P., Swaminathan, M. S. and Natarajan, A. T. 1957 Awning induced in wheat by treatment with radio-active phosphorus.

Wheat Inf. Service No. 5, pp. 4-5.

54. Paul, N. B., Vyas, N. D. and Sen, A. 1956 Studies on inoculation of soil with Azotobacter.

Proc. nat. Acad. Sci. India, 24 (A) : 542-551.

55. Pradhan, S. . . . . 1957 The ecology of arid zone insects (excluding locust and grasshoppers).

Human and Animal Ecology, pp. 199-240. UNESCO Publication.

56. Pradhan, S. and Bhatia, S. S. . . 1956 Bioassay of insecticides. V. Relative toxicity of some important insecticides to certain species of stored grain pests.

Indian J. Ent. **48**(1) : 34-40.

57. Pradhan, S. and Bindra, O. S. . . 1956 Studies on resistance to contact toxicity of *gamma* BHC suspensions by successive instars of *Schistocerca gregaria* Forsk. and certain associated factors.

Indian J. Ent. **18**(2) : 93-111.

58. Pradhan, S. and Srivastava, H. M. L. 1956 Increased activity of insects associated with increase. pick-up of insecticide at higher temperatures.

Indian J. Ent., **18** (1) : 78-79.

59. Prasada, R. & Joshi, L. M. . . 1956 A simple and inexpensive substitute for hypodermic syringe in field infection studies with wheat rusts.

Indian Phytopath. 9 : 212-13.

60. Prasada, R. and Sreekantiah K. R. 1956 Identification of biotypes within physiologic races of wheat stem rust.

Indian Phytopath. **9** : 209-11.

61. Radhakrishna Murty, B. and Swaminathan, M. S. 1956 Intraspecific differentiation in *Nicotiana tabacum.*

Indian J. Genetic., **16** : 88-97.

62. Raheja, P. C. . . . . 1956 Fertilizers—the answer of falling fertility.

Indian Fmg. **6** (4) : 17-19.

63. Raheja, P. C. . . . . 1956 Your crops.

Indian Fmg. **6** (5) : 17-20.

64. Raheja, P. C. . . . . 1956 Role of phosphate in crop-production.

Proc. 11th Meeting Crops & Soils Wing. Bd. Agri. 2., Anm. Husb. India.

65. Raheja, P. C. . . . . 1956 Role of organic manures and chemical fertilizer in crop production and maintenance of soil fertility. General considerations.

Proc. 11th Meeting, Crops & Soils Wing, Bd. Agric. & Anim. Husb. India.

66. Raheja, P. C. . . . . 1956 Plant issue test as a means to determine soil deficiency in nutrients.

Proc. 11th Meeting, Crops & Soils Wing. Bd. Agric. & Anim. Husb. India.

67. Raheja, P. C. Dhillon, H. S., and Luthra, G. L. 1957 Fertilization investigations in maize.

Indian J. Agron. **1**(4) : 221-235.

68. Raheja, P. C., Sen, S., Khan, A. R., Chandnani, J. J., Yawalkar, K. S., Bains, S. S., Gandhi, R. T. & Ganguly, B. D. 1956 Improvement in agronomy of wheat crop. Wheat Research Workers Conf. Simla.

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